Mechanical World — June 1958

RAILWAY REGENERATION

THE railways are in course of being changed from a scheme planned something like a hundred years ago and intended at that time to last for ever, to a re-equipped organization designed to retrieve the best of what is left of a diminishing near monopoly. There is little that is an exclusively railway province nowadays. One can travel quicker by air between the important business centres; one can travel independently, if more slowly, by road to the same places or anywhere else; and there is sometimes no need to travel at all so comprehensive have telecommunications become.

Road transport as it was known two hundred years ago was seriously affected by the provision of canal transport. Both were adversely affected when the railway came on the scene. Now we have the aeroplane, the telephone, radio and television, and in the meantime road transport has recovered completely with the coming of the motor car and now threatens the railway system. So the railway system is being modernized to enable it to survive, and something is being done, with less ostentation, to improve (but not extend) the waterways: it is a case of doing something at least as well, as cheaply and conveniently as can be done by a rival system. And with all this there is still the helicopter to think of, not as it is now but as it might become.

In anything so large and established as the oldest railway system in the world there is bound to be much which appears dependably permanent, and certainly enough to provide ample scope for ingenuity in providing excellent service with high efficiency. For such an object, modernization is not something to be done once and for all—that was the original idea, and it is a hundred years out-of-date. It is something that must go on all the time, which means that a railway system to be continuously successful must be a self-regenerating organism, making enough money for that purpose. If it cannot operate without loss and requires periodic gratuitous injections from outside then it is clearly in the latter stages of a declining life cycle. A vital industry is propelled by the willing efforts of all those who, concerned in its working, benefit from the fruits of a regenerative policy. In fact railway working today is very much an occupation for the enthusiast.

MARINE MYSTERY

THE announcement by a big shipbuilding-nuclear power group to go ahead with the design of nuclear-powered ships, adds to the prospect which is opening up almost daily of the new industrial age.

In terms of present nuclear technology, the nuclear-powered ship will have to be big, probably (though not certainly) bigger than the present average. This is because of the large size of the power plant, and also because of its high cost which has to be matched by high earning power which in turn requires more cargo space.

One charge of nuclear fuel will carry such a ship over many sea miles without refuelling, which certainly cuts out any time at present absorbed in bunkering at each end of a journey and enables that time to be usefully employed at sea. The daily cost of a large ship is considerable, and that of a nuclear-powered ship will very likely be so high that a maximum of carrying days will be of the utmost importance. A quick turn-round of a very large ship would mean mechanization of cargo handling with a new and higher degree of facility. If that could be done with unusual speed it might also mean the introduction of a relay system of crewing, otherwise there would be no leave for years.

There is no substitute for experience in such matters and the ultimate conditions depend on the effect of combining the cost of the ship with the cost of the power. If the figure is high, then the problem is one of high efficiency mechanization. If it is low then time will not matter nearly so much. The nuclear land power stations promise cheap electricity but the scale is far beyond anything conceivable in ship size. On the other hand, nuclear plants may not always be so expensive as they are now, or so bulky and heavy. Altogether the future of the subject has an exciting obscurity.

LOG SHEET

Planned Maintenance

The importance of the planning and control of plant maintenance to reduce production costs was stressed by Mr. R. J. Clarke, of Production-Engineering Limited, at a meeting of the Birmingham branch of the Institute of Industrial Technicians.

Mr. Clarke said that maintenance was a largely unexplored field for organization, work study, technical planning and control. Despite the effort devoted to maintenance in this country, there was surprisingly little organized practice. There were five reasons why organization should be undertaken: (1) to reduce plant running time; (2) to improve product quality; (3) to reduce maintenance costs; (4) to provide means to pay improved earnings to maintenance workers; and (5) to provide information as a basis for management accounting.

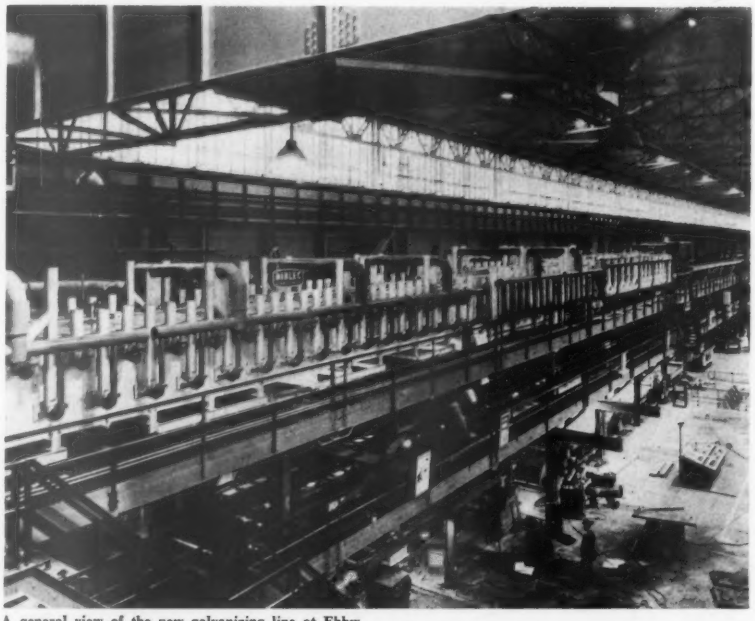
Management had to decide whether to apply preventive or breakdown maintenance. The organization of preventive maintenance could be done by a series of steps. These included:

1. Identification (plant listing and numbering).
2. Planning (detailed technical consideration of how, where, by whom and how often a job was to be done).
3. Programming (setting out the work on a uniform basis).
4. Job issue (issuing instructions to the artisan staff).
5. Reporting (receiving information on work done).
6. Recording (entering up control chart and recording on technical history sheet).
7. Follow-up to ensure uncompleted work is finished.
8. Revision (to ensure work schedules are corrected in the light of previous experience).
9. Plant review (consideration of plant and operating economies in the light of performance revealed from maintenance practice).

Mr. Clarke defined control as setting a standard of performance and measuring what had happened against it. The practicability of setting standards depended largely on the repetitiveness of work. Work study could be used in setting standards, for the study of jobs almost invariably led to improvements. The decision to apply different sorts of standards rested principally on costs—mainly the cost of staff needed to apply them and the return likely to be obtained.

Largest Galvanizing Line

Designed to produce 10 tons of either galvanized sheet or coil per hour, the new Birlec-designed and built galvanizing line at the Ebbw Vale works of Richard Thomas and Baldwins Limited is Britain's largest and most modern plant of its kind.



A general view of the new galvanizing line at Ebbw Vale, giving an impression of the great size of the installation which is 700 ft long, 36 ft wide and 30 ft high

Nearly 700 ft in length, 36 ft wide and 30 ft high, the line takes strip of up to 48 in. width. Driven by roller conveyor at speeds up to 250 ft per min through all the stages of cleaning, heat-treatment, pickling, coating, shearing to size, and inspecting, the strip is processed in one continuous operation. Apart from electrical and mechanical maintenance staff only six men per shift are required to control the equipment.

The strip is cleaned by passing through a gas-fired flame-heated furnace after which its temperature is further raised to 1550° F in the heating section of the reducing furnace by gas-fired radiant tubes. In the following section, which is electrically heated, the strip is maintained at a constant temperature where surface oxide is reduced, and annealing takes place. Entering a controlled cooling section it passes into the galvanizing bath at 950–1100° F, depending on the requirements of the bath, which is self-maintained at approximately 850° F by the temperature of the strip passing through. Electric heating elements are provided for initial melting of the bath, and boosting during topping up.

The strip emerges with a coating which has an adherence sufficient to withstand drawing and forming operations up to the limit of the steel base, and represents a radical departure from earlier methods of sheet steel galvanizing.

Throughout the line, from entering the reducing furnace to emerging from the zinc bath, a protective atmosphere of dissociated ammonia is supplied to all chambers by the Birlec ammonia cracking plant.

The total electrical rating is approximately 1000 kW plus 50 kW for each of the two ammonia dissociators. For the gas-fired sections, coke-oven gas with a gross

calorific value of 500 b.t.u. per cu ft is used, the flame heater taking 18,000 cu ft per hr and the reducing furnace 21,000 cu ft per hr.

Honeywell Brown gas and temperature control equipment has been used throughout.

Checking Fuel Gauges

To any aircraft pilot, and particularly a jet pilot, the fuel indicator is one of the most important instruments. His reserves, although large in quantity, are small in time and the fuel gauge must be correct to within a few gallons. Aircraft manufacturers often require checks to be made on pre-production and production installations and for this purpose Waymouth Gauges & Instruments Limited have specially equipped a van which normally carries a crew of two and has a special body built on a standard Austin 3-ton chassis and cab. Built-in steps can be drawn down on each side to give access to the control panel and crew compartment just behind the cab. A third pair of retractable steps leads to the pump compartment. Roller doors give access to each compartment which are separated from each other by a flameproof bulkhead. In the forward compartment, engineers have metal lockers for their special equipment and also a console on which is mounted the calibration equipment. To protect the delicate instruments the desk is mounted on anti-vibration mountings.

Behind this space, in the pump room, is housed a 28 gpm electrically driven pump and proving tank. This tank is used to test that the pump and the Brodie Kent meter is registering accurately. Use of the tank is simple. Sixteen gallons of fuel are pumped from an external fuel supply through the highly accurate Kent meter into the proving tank. After sixteen gallons have passed the meter an automatic control turns off the pump. A graduated sight glass on the proving tank is examined and this should also show sixteen gallons. If the sight glass shows a slight error in the Kent meter this is adjusted on the meter until an accuracy of better than 0·1% is reached.

Very special precautions are taken to see that uncontaminated fuel, free from water and air, is pumped into the aircraft tanks. A Streamline filter unit takes out traces of water and any foreign solid matter and

COMPRESSORS AT VAUXHALL MOTORS.— One of the largest industrial compressor installations supplied by the Atlas Copco Organization is this group of seven machines at the Luton Works of Vauxhall Motors Limited. The machines are of two-stage, double acting water cooled type having a vertical low pressure cylinder and horizontal high pressure cylinder with a double bank intercooler between stages and each has a free air delivery of 3,220 cfm. The motors are the Bruce Peebles 6.6 kV synchronous over-hung type with separate excitation.

the fuel then passes through an air separator. By an arrangement of pipes and control cocks, fuel can be pumped into the aircraft or drained without having to change over the fuel hoses. A by-pass is fitted to the pump so that, should it be preferred, fuel can be pumped out of the aircraft by the aircraft pumps. During this operation the van is by-passed but the fuel quantity still controlled and registered by the meter.

External sockets are built into a panel on the side of the van to connect the 440 volts a.c. supply for the pump and the 240 volts a.c. supply for the internal lighting of the van and supply to a distribution board in the forward section.

The fuel gauge indicator engraving in each aircraft type is based on a calibration conducted on the prototype aircraft. After the indicator has been engraved and installed an accuracy check is made. The first and possibly second production aircraft installation is also accuracy checked to prove that the fuel gauge installations and the aircraft systems are consistent.

In order to establish the indicator engraving it is necessary to determine the capacitance/volume or mass characteristic of the tank. There are two methods of doing this calibration depending on the type of fuel gauge fitted to the aircraft.

To calibrate a Smiths-Waymouth uncompensated gauge a Q-meter is used together with a laboratory standard variable air condenser. The condenser is connected to the Q-meter in parallel with the aircraft tanks via a 50-ft co-axial cable. Fuel is pumped into the tank and the capacitance change recorded at approximately sixteen points from tank empty to tank full. The fuel increments required can be set on the Brodie Kent meter, which will cut off automatically at the required volume. The fuel is then drained and the measurements repeated. Both curves are then plotted but the ultimate indicator engraving is based on the draining curve as this is the condition of most interest to the pilot. The method of calibrating a compensated fuel gauge is similar, except that a three-terminal capacitance bridge is used instead of a Q-meter and capacitance measurements are made using the bridge null point as the reference point.

Electrical supply for the equipment is obtained from a power pack and a 115-volt 400-cycle inverter installed in the van.

Titanium Melting Plant

The titanium melting furnace which was put into commission recently at the Kynoch Works of I.C.I. Metals Division at Witton, Birmingham, is the largest in Europe and is one of three furnaces supplied to I.C.I. Metals Division by W. C. Heraeus G.m.b.H. (Western Germany) for the production of

double-melted ingots up to 4200 lb in weight, by the consumable electrode arc melting process. The furnaces were delivered in January and the first 1-ton ingot was produced a little over two months later. Within a few days, an ingot weighing 4200 lb—the largest ever produced outside the U.S.—was successfully melted.

The availability of such large ingots widens the scope of fabricating techniques which can be applied to titanium. In particular, it makes possible for the first time the rolling of slab into long-length coils by strip rolling techniques without the necessity for welding small coils together. It also increases yield by decreasing surface/volume ratio. Any reduction in process scrap is, of course, a most significant factor, because titanium is still a relatively expensive metal.

Among several interesting features is the fact that the melting current employed is higher than has ever before been used for this purpose in Europe, which facilitates more complete melting and results in ingots of improved homogeneity and better surface quality. The furnace will normally operate with a high degree of vacuum, a pressure of under 10 microns being maintained throughout a melt.

Facilities are also provided for melting under a reduced pressure of an inert gas, should this be required.

A feature which reduces "down time" enables the first-melt ingot to be withdrawn into the upper part of the furnace and held in vacuum while the larger-diameter crucible necessary for the second melt is fitted. Another allows the second-melt crucible, containing the double-melted ingot, to be sealed by a plate valve and withdrawn from the furnace for cooling, so that the furnace can immediately be prepared for another melt.

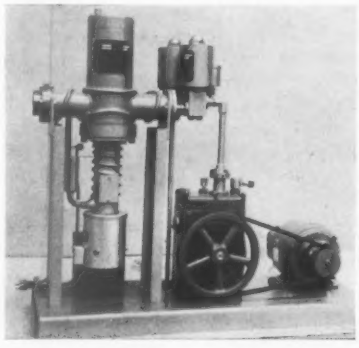
All operations are carried out by remote control and the furnaces are installed in massive reinforced concrete cubicles affording complete protection. In the control room, optical systems give operators a clear view of the furnace interior throughout the melting process. Other instruments record essential technical data at all stages and incorporate a system of fault indication and location. The effect of such completely protective measures is to allow considerably greater flexibility in melting operations, itself an important advance in the technology of titanium melting.

In 1955, eighteen furnaces were needed for an output of 1500 tons a year; today, three are sufficient to produce over 2000 tons a year.

Semi-automatic Vacuum Pumping System

A very compact vacuum pumping outfit designed for semi-automatic operation was recently supplied to Switzerland by Edwards High Vacuum Limited. The illustration shows the appearance of the unit which comprised a Speedivac 1SC50 rotary air ballast pump, displacing approximately 1·7 cu ft per min, backing a Model F203 fractionating oil diffusion pump capable of attaining an ultimate vacuum of 5×10^{-7} mm Hg.

An electrically operated water cooled baffle and isolation valve is mounted on the diffusion pump and a ½ in. magnetic valve and air admittance valve are mounted in the backing and by-pass lines. The



Compact outfit capable of attaining an ultimate vacuum of 5×10^{-7} mm Hg

pumping sequence is remote controlled through a 7 ft lead from the control unit and the operator can set the pumps in motion and operate the various valves by merely pressing buttons of the control panel. The outfit occupies the minimum amount of floor space and is giving complete success in operation.

Block Storage Heaters

"For the whole country, the difference between the daytime peak demand for electricity, and the demand occurring at, say, 3-0 a.m. during the winter is not less than about 10,000 megawatts. At the current costs of building and equipping thermal power stations this represents a capital value of, say, £600 million lying idle for the greater part of every night (equivalent to about one third of the year). Idle transmission and distribution capacity during the same hours will represent another huge sum.

AXLE-WELDING MACHINE.—This Unionmelt installation supplied by Quasi-Arc Limited to the Birmingham works of Fisher and Ludlow Limited, has reduced the time taken to weld axle cases to one-eighth of that taken by former manual methods. Two automatic welding heads are traversed on a runway by separate motors. The two halves of the axle are held by air-operated, self-locking clamps which align the pressings. The same mechanism operates the half troughs which hold the Unionmelt powder on the weld area

Moreover, the closing down of so much plant overnight and putting it back into service each morning results in some loss of overall thermal efficiency".

This statement was made by Mr. E. Bates, Chief Commercial Officer of the North Eastern Electricity Board, Newcastle upon Tyne at the Electrical Development Association's 21st Annual Conference. In an efficiency-conscious age, said Mr. Bates, it was considered that in block storage heaters lay one of the most promising means of improving the load factor.

Mr. Bates outlined a few of the advantages of this system of electric heating. Heating by block heaters had a virtue that had been remarked on by many users, namely that rooms had already achieved full comfort conditions when they were first occupied in the morning. In commercial and industrial premises personal comfort paid dividends by better output from employees, and better response by customers in the case of shops.

Ability to heat an existing building without the need to alter or add

flues or make any special ventilation arrangements was important and would be so regarded by the owner or occupier concerned. The capital cost of a block heater installation was considerably less than that of an orthodox hot water central heating system with which it was fairly natural to draw comparison.

Practical Training for Mechanical Engineering

The Institution of Mechanical Engineers has issued a Report on Practical Training for comment by interested parties. The Institution requires every Associate Member, amongst other qualifications, to have 'been adequately trained as a mechanical engineer', and the present interpretation of this is to recommend a period of eighteen months' training in mechanical engineering workshops in industry. It was felt that more specific requirements should be stated, and it was for this reason that a committee was appointed to review the subject.

BOILER CONTROL.—The control panels in the new boiler house at Vauxhall Motors Limited, Luton showing the Kent instrumentation. The new space-heating and steam-generating plant consists at present of five 70 million B.t.u./h high-pressure hot-water La Mont boilers and two 27.5 million B.t.u./h "package" steam-generating boilers, all of which are oil-fired and equipped with Kent instruments and automatic control. At the left of the picture is the boiler-control panel, each section of which contains the instrumentation for one boiler. At the right is the main distribution panel from which heat distribution to various works consumers is recorded and controlled

FAIREY ROTODYNE, THE WORLD'S FIRST VERTICAL TAKE-OFF AIRLINER.—After climbing to 4 000 ft as a helicopter the power to the rotor of the Rotodyne was then closed down and transferred to the forward-facing propellers, and the Rotodyne flew forward in straight, level and steady flight as a conventional fixed-wing airliner, with the rotor "free-wheeling". The procedure was reversed for landing. This very important stage in flight development, that of transferring in flight the power from the rotor to the forward-facing propellers, has been achieved in only five months

The report deals primarily with the practical training of engineers who take full-time degree courses or sandwich courses and concludes that some form of practical training is essential for mechanical engineers, and that such training should be planned scientifically. A suggested syllabus of practical training is put forward as a guide. This consists of a period of basic training during which a series of exercise components should be made under skilled supervision in a training workshop, and a period of secondary training in various departments and offices in industry. The total training period advocated is two years. The report accepts the point of view that the extent and nature of practical training should be related to the final career which has been chosen and that what is appropriate to a production engineer may not be appropriate to a man interested in research.

Inventions Competition

A novel approach to overseas trading is being made by Freeman, Taylor Machines Limited, of Syston, Leicester, textile and general engineers and specialists in stainless steel plant, who have instituted a search for original inventions which can be exploited mainly on the export market. A national competition has been launched by the firm and the winner will receive a prize of one hundred guineas and a royalty. Royalties and cash awards will also be paid to runners-up whose inventions are acceptable.

Any kind of invention is eligible for the competition, though work must meet a universal need and be "down to earth". Preference will naturally be given to inventions connected with engineering, though the company say that any suggestions will be considered other than the manufacture of articles concerning clothes and food. The guiding principles are that inventions should be original and practical.

Tunnelling Conveyors

On the Kent side of the Thames, the 28 ft dia tunnel now under construction between Dartford and Purfleet is being driven into the chalk at the rate of about 80 ft per month. On the Essex side, it still has 300 ft of awkward terrain to go before entering solid chalk.

Four shaker conveyors complete with duckbill loaders, built by Distington Engineering Company Limited, are being used. Working in a sticky mixture of gravel and chalk and with gradients of up to 1 in 10, the duckbill loaders scoop up the material and deposit it on the shaker conveyors, each of which is capable of being extended to a length of 100 yd. From the shaker conveyors, the material passes to belt conveyors which load it into crushers, where it is mixed with water and pumped to the surface.

Maintenance and Repair of Water-sealed Gasholders

Water-sealed gasholders, often popularly (and incorrectly) termed "gasometers", have a very long period of useful life, and, in past years, this reliability has tended to promote a certain amount of laxity in some quarters as regards their maintenance and upkeep. It is now recognized, however, that, both from the points of view of safety and of economics, it is essential to adhere to a systematic plan of inspection, overhaul, and repair. This article outlines the main points which are involved

By A. R. MYHILL, F.R.I.C., M.Inst.Gas E., M.Inst.F.

ALTHOUGH there are several different kinds of gasholders in use, including those of the high-pressure type and those working on the piston principle in which the roof of the holder forms a rising and descending platform working within a shell, by far the greatest proportion in Britain are of the water sealed type, built on the principle of an inverted tank (known as the "bell") which is capable of rising or falling according to the entry or withdrawal of the gas. The bell, when containing gas, rests or floats on a main water seal constructed in the form of a tank which is usually, but not necessarily, located below ground level. With most large holders, the tank is of semi-annular pattern, having a central "dumpling" constructed as a shallow truncated cone rising to a level which may, or may not, be above the general height of the tank

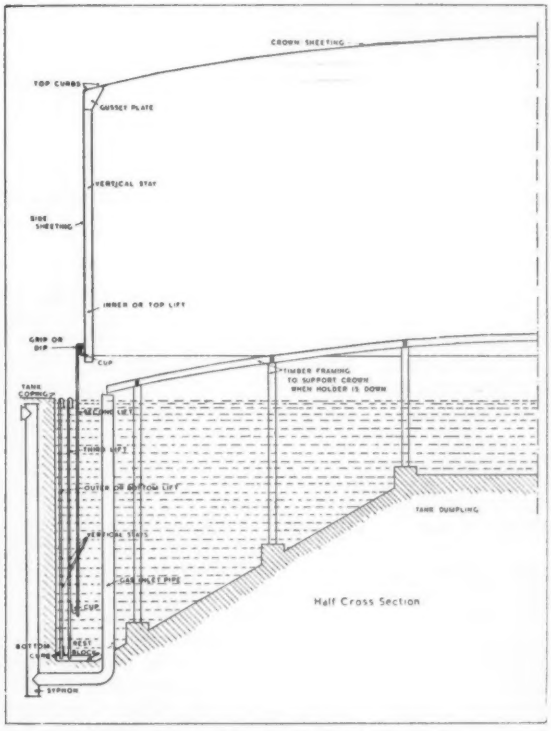


Fig. 1. Half-section of four-lift holder with untrussed crown

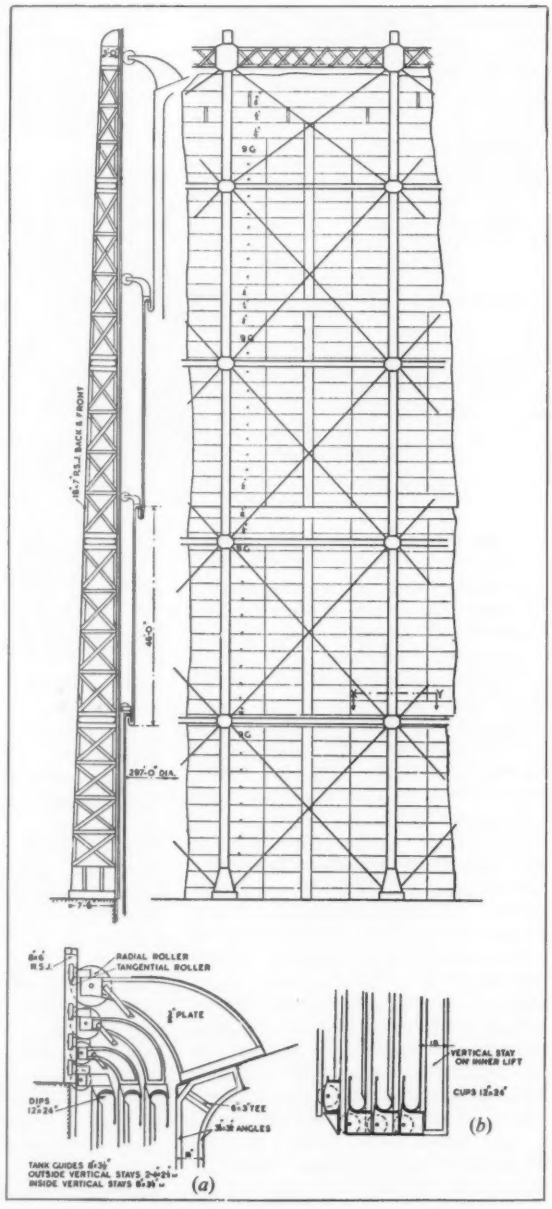


Fig. 2. 12½ million cu. ft. guide-framed gasholder. Details of (a) top and dip carriages; (b) cup and bottom carriages.

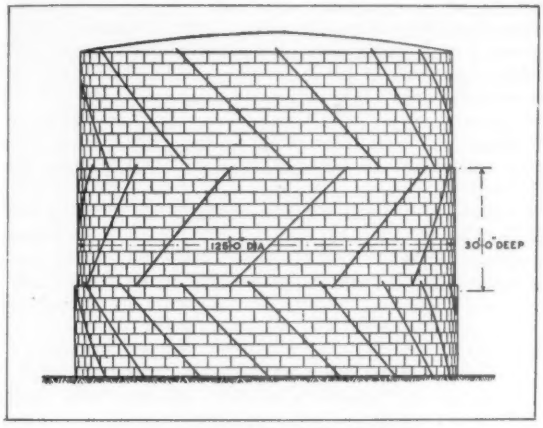


Fig. 3. 1½ million cu. ft. spirally-guided holder

water. This arrangement serves to economize water and minimizes water leakage. The dumpling often serves as a support for a framing which accommodates the "crown" of the bell when the latter is fully deflated. The crown itself may or may not be internally trussed; this is generally done in the case of large holders.

All except the smallest holders are of telescopic construction, having several "lifts" or sections which rise and fall with the filling and emptying of the holder, the inner lift being topmost, and carrying the slightly domed crown. When fully deflated, all the lifts are telescoped together below the level of the water in the tank.

Gas-tightness is attained, when the bell is inflated, by the provision of annular water seals ("cups and grips") between the lifts.

Fig. 1 shows a half-section of a four-lift holder with untrussed crown. The bell is shown partly in the second-lift stage of fullness. The third and fourth lifts are submerged in the tank. When gas is put into the holder, the bell rises until the cup extending around the lower edge of the second lift engages in the grip (or inverted cup) on the upper edge of the third lift, so that the third lift becomes sealed in the annular water channel in the cup. This lift now rises and eventually carries with it the fourth lift and its water seal. The depth of the water seals are such as to withstand the gas pressure produced by the weight of the bell. Any tendency for tilting of the bell during rise and fall is checked by the provision of guide rails and rollers.

Water-sealed holders are divisible into two classes; column-guided, and what is called "spirally-guided", though the principle used is that of the helix. In the former, the rollers are mounted on the top of the dips (or grips) and on the crown, and also on the under side of the cups and on the outside of the outer lift. These rollers are located at an even spacing around the periphery of the holder, and run in vertical channels attached to the columns. The columns are connected by horizontal girders and by cross-bracing to form a lattice framework in which the bell rises and falls. A typical arrangement is shown in Fig. 2.

In a spirally guided holder there are no columns. Rigidity is provided and tilt prevented by means of guide rails attached to the side sheets of the lifts. These rails are evenly spaced around the periphery, and form,

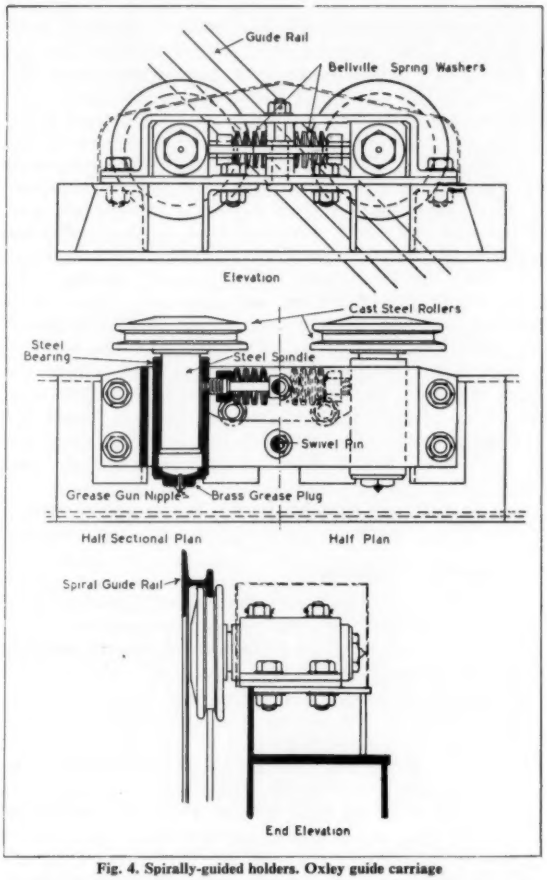


Fig. 4. Spirally-guided holders. Oxley guide carriage

in effect, a steeply inclined helix on each lift, generally arranged with alternatively left and right inclination on consecutive lifts. On rising or falling, the lifts rotate along the helix. Guide carriages bearing pairs of rollers are located on the grips, the rollers of each pair running on opposite sides of the rail.

Fig. 3 shows a typical spirally guided holder, and Fig. 4 shows details of the Oxley guide carriage.

The Gasholder Committee of the Institution of Gas Engineers has for very many years directed attention to the necessity for adequate and systematic inspection and maintenance of gasholders, and has stressed the importance of keeping full records of their condition and of any maintenance and repairs found to be necessary during the life of the holder[1]. With this end in view, standard record sheets have been compiled which indicate to the gasworks engineer what items of supervision are considered essential. The recommended scheme, which is often made use of in conjunction with insurance contracts, provides for the daily inspection of the holder components, a more detailed examination once per week, and the keeping of very comprehensive quarterly and annual records which are retained permanently in the office and include reference to all fresh painting and repairs which have been carried out during the period. Should any repairs have to be repeated, as in the case of the patching of corroded plates, etc., or if any component shows progressive deterioration, special notes are made.

Gasholders have a very long period of useful life and it is not unreasonable to expect at least 60 years of service. There are, in fact, several holders at work in this country which are over a hundred years old. Because of this reliability there has, in the past, been a certain amount of laxity in the maintenance of many of the older gasholders. In the 1929 report of the Chief Inspector of Factories, attention was directed to the need for proper inspection of gasholders, and an extensive investigation over a period of several years was carried out which revealed that, in over 1200 gas works in the country, satisfactory periodic examination was being made in only 51% of such works. The works under consideration included very many small undertakings, and the proportion represented considerably more than 51% of the total gas made. The position is very much better at the present time. With the policy adopted by the nationalized gas industry of integration of gas supply to outlying districts from large centralized stations, many of the smaller and less efficient gas works have been demolished, and unsatisfactory holders removed.

It is true to say that all gasholders are now subject to satisfactory periodic examination and maintenance.

Items needing attention

It will be of interest to consider specific points which have to be considered in maintaining this service.

Attention must be given to factors relating to possible failure of components due to

(1) Ageing of metal.
(2) Corrosion.
(3) Effects of cold weather.

Items of maintenance and repair include attention to

(1) Individual components of the holder.
(2) Levels of fixed and moving parts and of water surfaces.
(3) Lubrication.
(4) Painting.

Particular components which need periodic inspection include:

(a) Side and crown sheeting.
(b) Carriages and rollers.
(c) Columns and guide rails.
(d) Cups and grips (dips).
(e) Water tanks.

Side and crown sheeting

During the period of actual working of the holder, examination of the sheeting is usually made by inspection from the outside only, although even with a working holder it is generally possible to obtain useful information regarding the internal condition of the sheets.

Gasholder sheeting is very much thinner than that employed for other kinds of container (as, for example, tanks for liquids), since the prevalent internal pressure is relatively low. Reinforcement by thicker plating is necessary at certain positions, as in the top curb of the inner lift and at the cups and dips. External examination is usually confined to noting pitting and gas leakages from holes in the sheets due to corrosion. Leakages can be detected by brushing the suspected area with soap solution. Most large holders are constructed of riveted sheets but some of the smaller modern holders are of welded construction.

With older holders, inspection of the sheets may reveal a considerable number of patches which have been put on to repair leaks, and this may cause concern, particularly where patches have been necessary along the wind and water line and along riveted seams. If leakage is found at positions at points in line with the edge of the inner lap, while the external condition of the sheets appears reasonably good, an internal examination is very desirable as the plates may have become grooved by internal corrosion close to the edge of the inner laps[2].

Failures of holders due to damage to sheeting are nearly always detected and remedied well in advance of potential danger of collapse. Nevertheless, a few disasters have occurred, particularly with old holders, due to sudden and unsuspected weaknesses, especially in the crown sheets. A recent example of this was the collapse of the crown of the holder in Sydney, Australia[3]. Holders over 50 years old should specially be inspected at the crown, as many of these were built of wrought iron, which, although often showing remarkable properties of corrosion resistance, suffers from ageing. This effect, while often not seriously reducing the tensile strength, allows the ductility to fall so low as to produce brittleness. Crown sheeting under these conditions often gives no warning, due to the fact that it is generally under a considerable degree of tensional stress in all directions, and fracture takes place by a split alongside a radial or circumferential seam. Although bad deterioration of the crown generally necessitates putting the holder out of commission for complete re-sheeting, in some cases, where it has been virtually impossible to spare the holder on account of lack of other storage capacity, over-sheeting of the complete crown has been carried

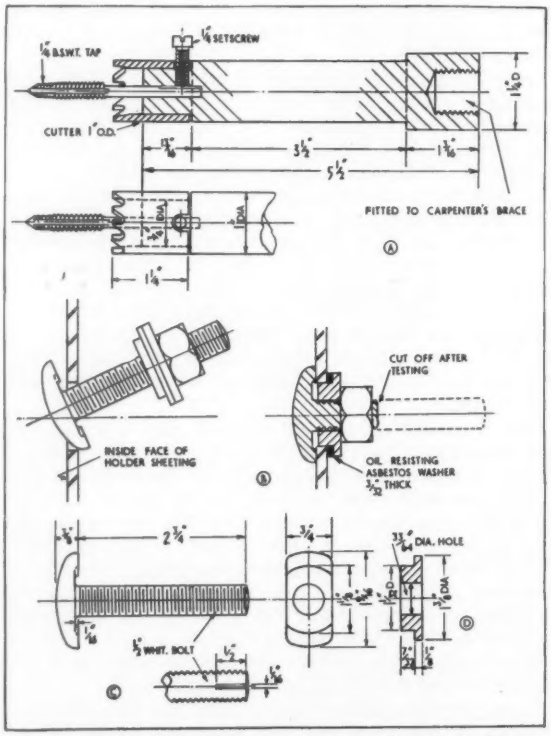


Fig. 5. Apparatus for removing test discs from gasholder plates. (A) Details of gasholder disc-cutting tool. (B) Method of inserting the patch plug. (C) Details of locating washer patch bolts for gasholders. (D) Locating washer

out. This can be done by bolting or welding, but the former is preferable since welding obviously necessitates complete stoppage of all gas leaks before the job can be carried out during the working of the holder.

The Gas Light and Coke Company, now incorporated in the North Thames Gas Board's Area, designed a special tool for cutting test discs out of side sheets and crown plates of a holder while in use. The I.G.E. Gasholder Committee considers it desirable to ascertain the internal condition of the sheets of any water-sealed holder which has been in use for 20 years[1] and the use of this tool makes it possible to carry out observations of the thickness of the sheets, and to note where corrosion has taken place on the inner side. The discs may be upwards of $\frac{3}{4}$ in. dia, and should be retained for future reference.

After cutting a disc from a working holder, a specially designed patch-plug is inserted in the hole, where it can be permanently bolted in position. Fig. 5, reproduced from the 16th Report of the Chairmen's Technical Committee of the I.G.E. (1954–55), shows details of the cutting tool and patch plug[10]. As the loss of metal due to corrosion is usually greater near lap joints, the discs should be taken out as near as possible to these points, including, if possible, part of the lap. Discs should be cut from side sheets and from positions near to the radial and circumferential laps on the crown plating.

The internal examination of holders was made compulsory by an amendment of Section 33(3) of the Factories Act, 1937 (Section 11(5) of the Factories Act, 1948) which now requires that: "In the case of a gasholder of which any lift has been in use for more than 20 years, the internal state of the sheeting shall, at least once in every period of ten years, be examined by a 'competent person' by cutting samples from the crown and sides of the holder or by other sufficient means, and all samples so cut, and a report on every examination signed by the person making it shall be kept available for inspection."

Carriages and rollers

It is essential that the lifts of a column—or spirally-guided holder should work smoothly through the carriages with a marked degree of precision. The clearance allowed on the carriages is very small, being even with the largest holders, not greater than $\frac{3}{8}$ in.

The carriages must be properly adjusted by a specialist workman, as inexperienced labour might result in disastrous failure. Adequate lubrication is necessary, and the rollers should be treated with the best quality grease at least once a month except in cases where a continuous oil bath is provided.

Intermittent lubrication with light oil is unsatisfactory as the oil rapidly becomes washed away during rainy weather. Grease gun or Stauffer lubricators are very satisfactory. Inspection of lubricator nipples should be made in order to avoid lack of grease by blockage. It is sometimes inconvenient to lubricate and examine carriages, rollers, cups, and grips on account of failure to supply proper hand-rails and fixed ladders. Provision should be made for these in designing the holder. Where they are absent it may be necessary to work with the holder partially deflated during this work. Attention to carriages and rollers is, perhaps more important in the case of spirally-guided holders than with the vertical column type. In a spirally-guided holder the rails are bent and twisted at the works before despatch to the site and have to be erected in a vertical plane at a true radius inside the tank. A small clearance between rails and rollers is essential to smooth working and to the avoidance of strain on the lifts due to temperature or temporary seizure of bearings due to lack of lubrication or corrosion. Badly worn or loose cup carriages must not be tolerated, and proper repairs can only be carried out by completely emptying the holder, since in normal working the cup bottom carrying the rollers is entirely within the gas or water space.

Faults due to cup-carriage wear, etc., can often be predicted by a bad tilt of the bell.

Cups and grips

Corrosion and pitting in the cups is often observed along the wind and water line. It is frequently noticed that this is more severe in multi-lift holders working mainly with the top and second lifts always out of the water. In such cases these lifts do not often "un-cup", i.e., they do not get submerged in the main water tank, and the water contained in their cups becomes contaminated by over-long standing in an atmosphere which may contain corrosive constituents such as sulphur gases, ammonia, etc., arising from works processes. As a result, corrosion increases at these levels.

Where practicable it is therefore always advisable to work a holder in such a way that all lifts enter the water in the tank at frequent intervals, preferably about once a day. This is a counsel of perfection in many instances, since there may be a risk of running short of gas if there should be an unexpected demand at a time when the holder is low. Practically all gas works, however, have several holders so that at least one of them can be kept in reserve for unexpected demands.

During periods of heavy rainfall, the level of water in the cups rises and the water flows over the top of the grip and down the sides of the holder, eventually reaching the tank, which itself is provided with overflow ducts. In order to keep down the concentration of contaminant in the cup water, arrangements should be fitted for taking the overflow water from the bottom of the cup at the level of the bottom edge of the dip plate by means of a pipe with an open top to avoid syphoning.

Cups should be periodically examined for deposits, either hard or soft. Hard deposits might cause damage and interfere with cupping and uncupping operations. The water seals should be frequently cleaned out. This can generally be done while the holder is at work, provided a supply of water is at hand to replenish the seal as the deposit is being removed.

The levels of the lifts and cup seals, and the horizontal distances of the lift plates from one another must be carefully checked from time to time and any undue variations or loss of cup seal regarded as serious. In this connexion the comprehensive annual inspection recommended by the Institution of Gas Engineers requires horizontal measurements to be taken from lift to lift at North, South, East and West points at the top cup, second cup, third cup, etc., and at the top of the water tank. Vertical measurements are required from top of grip to water level at N., S., E. and W. points at top cup, second cup, third cup, etc., and at tank top. The positions of rollers relative to guide rails are noted at the same time.

The allowable out-of-level figure for a new holder is only one inch, and any higher amount in a multi-lift

holder could be dangerous, particularly if the seals are low. This is particularly risky in a high wind, when extra tilting might cause the seal to blow. If this should happen suddenly, large quantities of gas might escape and the lifts could race downwards through the guides at a speed far in excess of the normal, and serious damage might be done to the structure.

Water tanks

Holder tanks may be of cast or wrought iron, mild steel, or concrete, and may be entirely below ground level, entirely above, or partly below and partly above. With metal tanks projecting above ground level, external joints must be inspected for leakage and corrosion. Since there are rails and carriages within the tank, these must be periodically examined. Unless the general performance of the holder indicates that there is any binding of rollers and guide rails, an internal examination is not often necessary, and is not usually carried out more frequently than once a year. While it is obviously more satisfactory to do this when the holder is completely empty and purged of gas, when a few of the crown plates can be removed for the entry of men into the inner lift and tank space, this is not always convenient, and the work sometimes has to be done while the holder is full of gas. This may necessitate the assistance of a professional diver entering the water outside the outer lift where there is room for this to be done. When a diver is employed, it is also a good plan to have the tank bottom and inner sides examined for cracks in the case of concrete tanks, in order to avoid percolation into the surrounding ground.

As in the case of holder cups, tanks are provided with overflow ducts to run excess water away where there is make-up due to rain, snow, etc., and overflows should be extended to the bottom of the tank internally, and slots cut in each side at the bottom, about 12 in. long. The top of the pipe should be left open to prevent syphoning, but covered with a perforated cap to keep out solid foreign matter.

Cold weather precautions [6 7]

In Britain precautions are always necessary to guard against trouble and often serious danger due to freezing of water in tanks and cups. Trouble may sometimes be brought about by heavy snow deposits on the crown, although this not generally serious. The effect of snow is to increase the pressure of the gas in the holder due to extra weighting, and in some cases (although not many), blowing of gas at the cups may take place where the seals are light. It is, therefore, advisable to keep the snow deposits as thin as possible, and where practicable, to lower the bell and have the snow shovelled or swept off the crown.

Icing troubles are always likely to be serious if left unattended, and spirally guided telescopic holders are a particularly heavy responsibility since, owing to the rotation of the lifts when the holder rises and falls, damage may be caused to attached members of the construction, as for example gas pipes within the holder and guiding rails. This is especially the case with holders of small diameter, where ice may form over the surface of the tank water, inside and outside the side sheets,

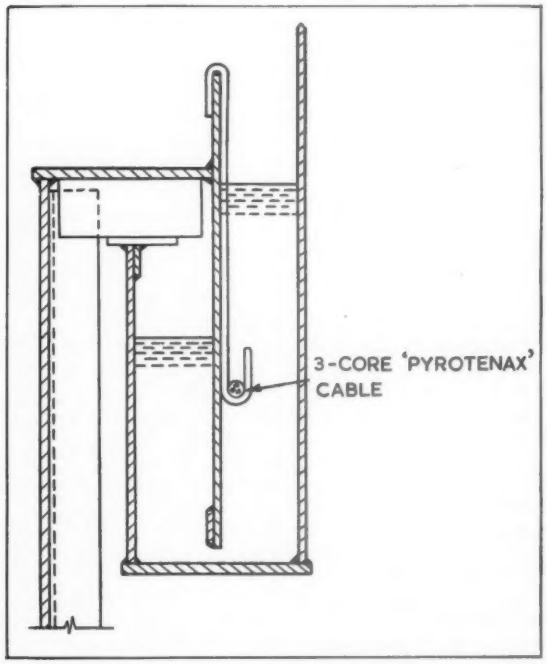


Fig. 6. Electric anti-freeze apparatus. Section of cups and dip of a water-sealed gasholder showing position of the heating cable

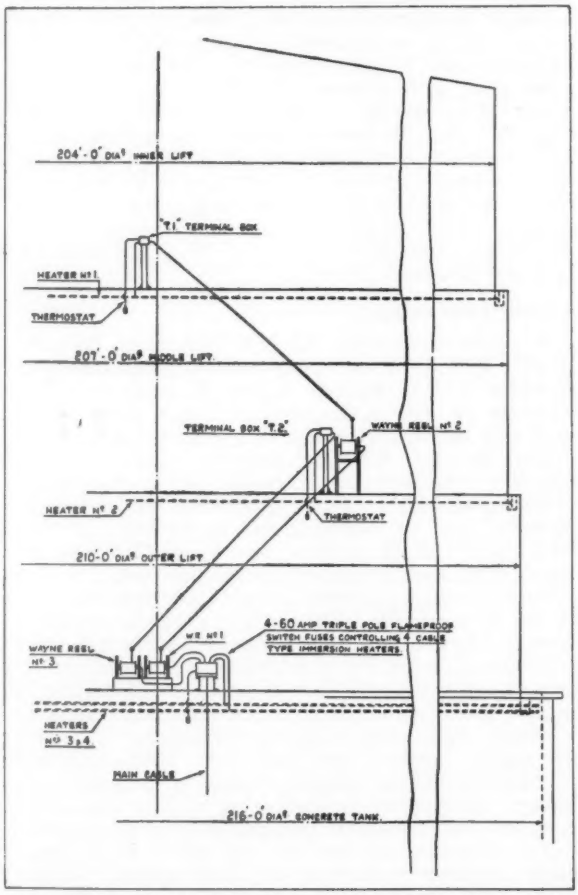


Fig. 7. Elevation of the fully-inflated South Gosforth gasholder, fitted with electric anti-freeze apparatus

Fig. 8. Flame cleaning of the side plates of a column guided gasholder

and this ice may extend inwards to a rising gas main within the tank. As the holder rises or falls the twisting motion may be imparted to the pipe which eventually cracks or becomes displaced.

All water-sealed holders must therefore be equipped with anti-freezing devices, and these may be heating by steam, hot water, or electricity, and they may operate in the annulus of the tank and in the cups. It is essential that the water in the cups should not only be heated, but also kept in circulation. Steam and hot water connexions, which may, for convenience be left disconnected during summer weather, are of rubber or metallic flexible hose. Electrical heating is very convenient and has the advantage that it can be applied where steam or hot water is not available, as for example, where a holder is located on an isolated site away from the gas-works.

The installation of an electrically heated de-icing system on a holder near Newcastle upon Tyne has been described by Garrett[8]. The holder is of the spirally-guided type, of 3 million cu ft capacity and having three lifts, the outer one having a diameter of 210 ft. The lifts are 31 ft deep each, and the cups 12 in. wide and 2 ft deep. The heating elements each consist of 700 ft. of triple-core copper-sheathed "Pyrotenax" cable (0·0015) star connected at one end and supplied with 10 yd of triple-cored 0·0145 lead-in cable for connexion to the 415 V three-phase, 50 cycle supply. The elements are laid in mild steel hook straps attached to the dip plates about 1 ft 4 in. below the cup water level. The arrangement is shown in Fig. 6. The electrical requirements are approximately 45 kWh per complete cup, or $\frac{1}{16}$ kWh per ft run.

The feed to the elements is by flexible armoured cable which is connected to each cup, and which re-winds on to Wayne self-winding drums according to the position of the lifts. The location of the reels and general layout is shown in Fig. 7.

Should the water in the tank or cups of a holder become so firmly frozen that the holder is in imminent danger of sustaining damage, and where it is impossible to effect a rapid thawing-out during its working period, it is nearly always necessary to isolate it from gas admission and delivery and to supply the area from another holder. A pressure gauge should be used during the idle period so that small quantities of gas can be admitted or released to keep the pressure normal and constant and so avoid strains due to pressure variations caused by expansion and contraction.

Ice formation frequently takes place more on the windward side of the holder and it may be advisable to supply protection in windy weather by hanging tarpaulin sheets at appropriate positions from gangways or other convenient structures.

Ice in the cups can often be removed by breaking up during the earlier stages of formation, but since the removal of ice will lower the water line, provision should be made for adding water (preferably warm) during the operation.

Should the cups be strongly frozen over, the holder should on no account be allowed to reach the "un-cupping" stage.

Opening of holder for internal repairs or inspection

Whenever a holder has to be entered for internal examination or repair, great care must be taken to avoid poisoning of workmen and danger of fire or explosion. In exceptional cases, men equipped with portable oxygen apparatus may enter a holder which is full of gas, entry being made through specially designed inlet boxes. It is then important that a man should be stationed directly outside the inlet box, provided with spare sets of breathing apparatus and with life lines. He should be in a position to summon immediate help if needed. Workmen inside the holder should be instructed to signal frequently by knocking with a hammer or by other suitable means to indicate that they do *not* require assistance. Absence of signals indicates danger. Normally, however, all internal work should be done with the holder emptied and out of commission. Even so, the holder must be completely isolated from communication with the gas distribution system. The intake and outlet mains must be isolated by completely blanking off with metal plates inserted between the flanges of main joints. Reliance must never be placed on the mere closure of a valve, unless it is of such a type as to provide a water seal which can be continuously kept full.

It is now general practice when taking a holder out of commission to purge it with an inert gas mixture before work is commenced, and afterwards to replace the inert gas by a copious supply of air[4]. The plant and process used for this purpose has been fully described by Birks[6].

The inert gas may be prepared as required in a generator which consumes town gas or oil without using appreciably more air than is necessary for complete combustion. It delivers a product nearly free from oxygen and carbon monoxide, and consisting mainly of nitrogen (85 to 90%) and carbon dioxide (10 to 15%). The purging procedure is regulated in such a manner that at no stage in the process there will be present in the holder a mixture of gas and air in explosive proportions. After the holder has been cleared, it is always advisable, where practicable, to remove a considerable amount of the crown sheeting so that access to the job can be made direct from outside.

Painting the holder

The main object of painting is, of course, the prevention of corrosion. A secondary object is the preservation of local amenities, and this is becoming quite important in town-planning and local government schemes[9]. Where, therefore, the two requirements can

be satisfied together, it should be the aim of the engineer to work to this end. In many small towns on the Continent, and in a few privately owned works in this country, painting of water-sealed holders is not practised and the bell is kept permanently coated with a film of oil, which is periodically replenished as the holder rises and falls from a thick layer of oil floating on the tank water. While this is cheap and effective as a preservative measure, the appearance of such holders is very bad from the point of view of local residents.

Owing to the unfavourable conditions prevailing at gas works, where corrosive gases and vapours are often present, it is absolutely essential to use only the best quality paint, and it is always worth while seeking the co-operation of reputable manufacturers who have had experience as regards paint composition for gas works use. If frequent painting becomes necessary on account of poor quality of paint, the cost of labour may well exceed that of the paint.

It is generally considered that colours which do not contrast too strongly with the surroundings are to be preferred. The exception is the use of green paint in country or wooded districts. Many green pigments used under gasworks conditions fade or turn blue or yellow, often in patches, and they will not blend with changing foliage colours throughout the year. Light grey or aluminium is a good colour to use, and a matte, not glossy finish is desirable. Aluminium paint has a good life, and withstands the corrosive action of salt-laden breezes near the sea. Alternatives are graphite-based and titanium-oxide paints.

Disfigurement of the side sheets is rather too common. This may be brought about by overflow of water from cups containing rust deposits, and this itself is a warning of possible structural corrosion. The lower lifts of the holder often become discoloured by immersion in the tank water which may contain floating coal and coke dust. This is sometimes countered by painting the lower lifts a darker colour and grading the tone upwards from dark to light. This scheme often has the effect of reducing the apparent height of the holder when viewed against the sky line.

Certain positions are often painted with a special non-drying paint. These are the wind-and-water lines of the cup-plates, grip skirting plates and tank plates. If this is done during the working of the holder, the water levels are reduced in order to facilitate painting as low down as possible, and care must be taken that no gas escapes through cupping or uncupping due to light seals.

One of the most important considerations in holder painting is the preparation of the surface. Here it is advisable to employ properly trained labour, since, as far as is practicable, all rust, loose mill scale and products of corrosion should be removed before applying a priming coat.

Although chipping, pneumatic and by hand is still largely practiced, there are great advantages associated with flame-cleaning, although it must be appreciated that in the case of holder sheeting the correct technique must be followed. Flame cleaning has the advantage of rapid removal of moisture, oil and grease from the surface and the breaking up of rust deposits by expansion due to the heat.

In certain cases, where deep and extensive corrosion has taken place, it may be advisable to hand-chip the worst parts and to follow up by flame cleaning.

Flame cleaning is conveniently carried out by oxy-acetylene blowpipe equipment of special design. Air-propane, Oxy-coal gas and other types of fuel can also be adapted to the system. Blowpipe tips may be flat (up to 8 in. wide) round or other shape for special positions. Where cylinders are used for both gases, the equipment can be made portable.

On angle brackets, curbs, girders, columns, etc., the procedure is normal and straightforward, but when cleaning riveted lap joints on side or crown plates, care must be taken to avoid injury to the joints by overheating. The operation can be carried out quite safely if care is taken to ensure that the flame is not directed towards the tape, and that it is progressed at a speed sufficient to ensure that distortion through overheating does not occur. The operation consists of making a number of passes over the area in a series of short forward and backward movements. The forward movements are limited to $\frac{1}{2}$ in., and the backward to $\frac{1}{4}$ in., thus treating the surface three times with each pass.

Rust, products of corrosion, or singly painted layers of paint, generally dry up and can be brushed away, but where there are several layers of thick paint, care must be taken that the nozzle orifices do not become clogged up. In such cases the blowpipe should be drawn slowly backwards to prevent paint residues being forced into the nozzle.

The surface immediately after treatment should be at a temperature of about 200° F, so that risk of distortion is slight. After leaving to cool to 100° F, a temperature easily judged by hand, the plate is wire brushed, dusted, and the priming coat applied. Moisture under the paint film is thus avoided, and owing to the decrease in viscosity of the paint, easy penetration of the surface crevices is ensured and a very adhesive bond formed between paint and metal.

Owing to the comparatively high temperature, the paint dries more quickly and often enables a second coat to be applied after two or three hours. One of the most important advantages of the process is that it permits of painting on many days of the year when conditions would be otherwise unsuitable because of the humidity of the atmosphere.

Fig. 8 is a photograph showing flame cleaning in operation on the side sheets of a column-guided holder at Leicester.

Acknowledgments

The writer is indebted to Messrs. Ernest Benn Limited for permission to reproduce Figs. 1, 2, 3 and 4 (Figs. 1, 3 and 4; "Terrace's Notebook for Gas Engineers and Students": Fig. 2; R. J. Milbourne, "Gasholder Design and Construction"); to the Institution of Gas Engineers for Figs. 5, 6 and 7 (Fig. 5; Communication No. 472, Figs. 6 and 7; Communication No. 353); and to British Oxygen Gases Limited for Fig. 8.

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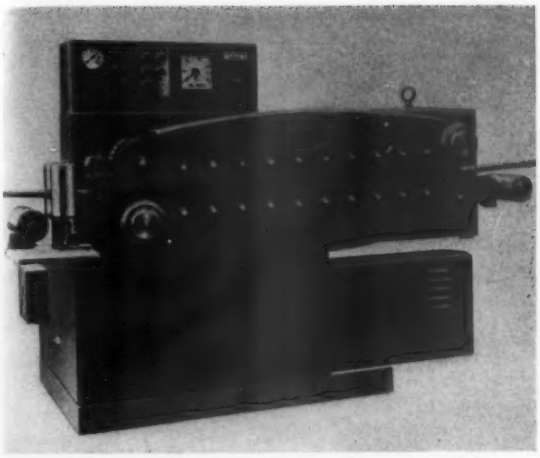
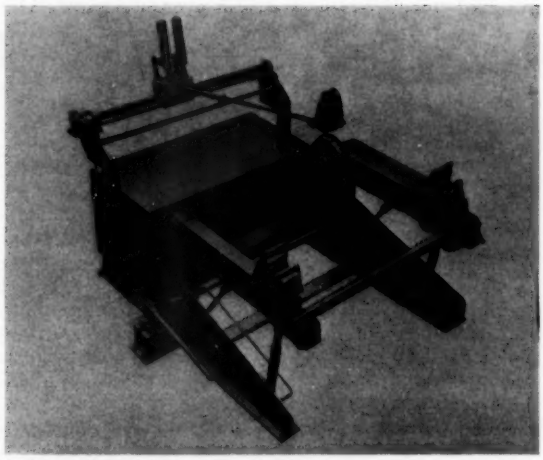




Left, the new LB caterpillar haul-off produced by Larmuth & Bulmer Limited. The instrument panel accommodates the lever for controlling cable grip, pressure gauge speed motor, measuring indicator and push button controls

Above, the independent take-up drum stand is made in six sizes covering drums up to 118 in. external diameter. This model incorporates a patented guide shoe on the traverse gear

Wire Rope-making Ancillaries—Haul-off and Take-up Drum Units

Two additions to their range of ancillary equipment for the wire rope and cable industry are announced by Larmuth & Bulmer Limited, Todleben Works, Union Street, Salford 6, Lancs.; a caterpillar haul-off and an independent take-up drum stand.

Where excessive strain on a cable can cause damage to sheathing, the direct in-line caterpillar haul-off method is often preferred to the usual type of haul-off drum. With the LB caterpillar haul-off the constancy of haul-off, is controllable through a variator and measurable by direct visual instrument reading. The two caterpillars each consist of an endless belt with steel cores. The cores carry special rubber shoes each being notched on its width to form a jaw to increase the grip on the cable and to assist the drive from the end rollers. Each caterpillar runs on carrying rollers having self-lubricating bushes and the complete assembly is mounted between a rigid supporting frame which can be dismantled for inspection easily and quickly. The whole assembly articulates on an independent axis to adjust the grip for various diameters of cable.

To make the grip of the cable more positive hydraulic pressure is exterted on the jaws by an accumulator charged by a small motor pump or compressed air. A pressure range up to 7000 psi can be pre-selected and controlled by a lever mounted in the instrument panel along with gauges indicating the operating pressure, speed of the drive and a measuring indicator. Pressure is relieved by a return spring to release the cable. The drive to the caterpillars may be by a constant speed motor if a drive from other cable making machinery is not available, but in either case power is transmitted through a P.I.V. variable speed box.

The main frame of the machine is of all-welded steel construction and installation is simplified by dispensing with the need for the conventional haul-off drum pit.

Two types of LB caterpillar haul-off machines available, Type 1000 suitable for cable diameters between 0·20 and 2·30 in. and which exerts a pull up to a maximum of 1000 lb with speed variations between 7 and 190 fpm and Type 3000 suitable for cables between 1 and 4 in. for pulls up to 3000 lb with speed variations between 7 and 130 fpm.

The LB independent take-up drum stand is mounted on a rigid steel chassis, and as no foundations are required the unit can be used as an interchangeable take-up stand to serve a number of machines according to the necessities of manufacture. It is manufactured in six different sizes, covering drums with external rim diameters from 29 up to 118 in. diameter.

The drum supported by a through shaft is raised and lowered by hydraulic jacks, the jack lift operated by either a hand or foot pump or by a hydraulic accumulator which is re-charged by a small motor pump. The system incorporates two speeds, one for a quick lift on light drums and the other for raising heavy drums.

For a wide versatile operation the winding gear is supplied with a motor with a slip characteristic which operates against a cable pull beyond a pre-set tension. By the use of a variable torque control, a tension may be chosen from a calibrated dial before starting up or it can be simply adjusted during running by operating the control handwheel. When the production machine stops and no longer surges the cable, the driving motor slips but maintains a constant pull on the cable. There is no risk of damage to the motor under these conditions as an auxiliary fan disperses any excess heat which may arise. This type of motor dispenses with the friction-clutch type of drive and enables the unit to be used for a wide variation of speeds and tensions. A take-up drum stand fitted with a squirrel cage motor is also available where the wide speed variation and duties are more stable.

For cables of $\frac{5}{8}$ in. dia and over, using cable pulls below 200 lb the traverse winding gear incorporates a patented automatic device by which a guide shoe places each coil in the correct position by the action of a "feeler" which is guided by the preceding coil. For cable below $\frac{5}{8}$ in. dia regardless of the tension the unit is fitted with the conventional device with pawls and rachet wheel.

In addition, to give the unit greater versatility for all tensions and diameters of cable, a variable speed device with electro-magnetic coupling gear can be supplied to provide a very quick return at the end of the traverse.

Guiding Satellite Rockets

The American Vanguard uses a triple gyro device for controlling flight and guiding the satellite discharge into orbit

THE satellite-launching vehicles developed under the management of the U.S. Office of Naval Research for the International Geophysical Year programme are each assembled by mounting three rockets of varying sizes one on the other to form one slender, bullet-shaped vehicle about 72 ft in length. Each three-stage rocket vehicle is for placing a scientific earth-satellite in an orbit circling the earth at a distance ranging from several hundred to perhaps 1500 miles from earth. The satellites contain scientific fact-finding instruments and radio equipment to transmit their information back to earth. Each rocket contains a gyroscopic guidance reference system the purpose of which is two-fold: (1) to tell the vehicle autopilot that the finless rocket has swerved off course because of sloshing fuel, air currents or other forces; and (2) at the command of a vehicle-borne timer gradually to alter the trajectory of the rocket so that the satellite-launching vehicle enters a globe-circling course some 300 miles above earth.

The gyro reference system contains three highly-accurate gyroscopes calibrated to a "memorized" heading reference in the three axes or directions of flight—one gyro each for roll, pitch and yaw. These instruments require bearings alike to within 10 millionths of an inch and are assembled in hospital-clean areas. Employees enter the gyro assembly rooms through air locks, passing over gelatin mats to clean their shoes. They all wear nylon smocks and hats; are not permitted to smoke and do not wear nail polish or carry a purse.

The instrument weighs about 4·6 lb and fits compactly into a cylinder 5·9 in. long and 3·07 in. dia. Its performance is such that it could measure the rate at which a glacier melts, or motion 3000 times slower than the hour hand on a watch, and its response is extremely fast. The high degree of sensitivity is due to virtually frictionless operation, created by mounting the gyro rotor assembly and gimbal in a special fluid.

When the 400-cycle operating power is switched on and the gyro rotor comes up to operating speed (12,000 rpm), it develops inertia with which it resists efforts to change direction of its axis rotation, and the resistance of the gyro can be measured. A gyro is predictable because the precession of the rotor is at right angles to the direction of, and in amount is proportional to, the amount of any force tending to disturb it.

The principal parts include a gyro wheel (or rotor), a gimbal surrounding and supporting the wheel, a signal pickoff and a torque generator. The gyro wheels look like four or five sectors glued together and are polished smooth to a millionth of an inch. The wheel is mounted inside the gimbal which in turn floats in a syrupy fluid in the middle of the gyro container and is supported at either end by miniature jewel bearings. The signal pickoff and torque generator units are at the ends of the gyro case.

Gyro filling units to get viscous fluid into the gyro to cushion the gimbal and provide it with a "floating" bearing to reduce friction. The waxy fluid is cycled through the gyro several times under vacuum to eliminate air bubbles

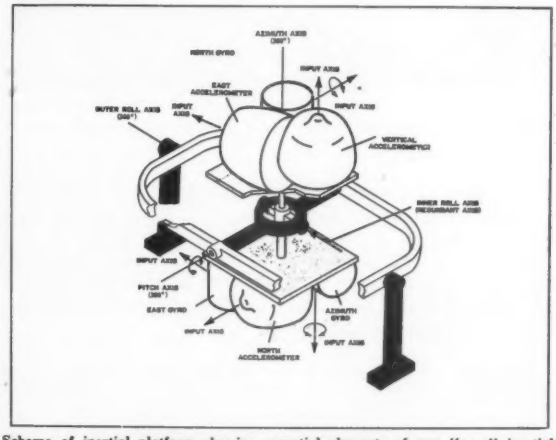
Floating a gyro was first achieved successfully at the Massachusetts Institute of Technology under the direction of Dr. C. S. Draper, and then developed into a production instrument by the Aeronautical Division of the Minneapolis-Honeywell Regulator Company in

the United States. The Martin Company, of Baltimore, is the prime contractor for the satellite-launching vehicle.

In non-floating gyros the gimbal bearings must be large enough to support the gimbal weight, and consequently more friction is introduced. By floating the gimbal and thereby counterbalancing its weight, the gimbal bearings can be small and light enough to act only as guides. Even though the gimbal weighs nearly one pound, it is guided by jewelled bearings similar to those used on balance staffs of fine watches. This floating method results in nearly frictionless operation, which is vital for the ultra-accurate sensing of movement.

Damping characteristics of the fluid result in a gimbal deflexion rate proportional to the rate of rotation of the gyro case. This characteristic, applied to the Vanguard system, works like this:

If the rocket rotates incorrectly—because of shifting fuel supply, engine irregularity, cross winds, etc.—about any of the three axes "memorized" by the three gyros (roll, pitch and yaw) even to an infinitesimal part of a degree, the gyromotors respond by rotating the gimbal on its jewelled bearings. This movement is sensed by the gyro signal pickoff and sent out as an electrical signal from the gyro through the auto-pilot amplifier to the error-correcting servo system. On the other hand the fluid restrains spurious movement of the gimbal and reduces non-linearities and prevents overstretching of the flex leads carrying operating current to the gyro mechanism.



Scheme of inertial platform showing essential elements of any "pure" inertial guidance system including three accelerometers, three integrating gyroscopes and four gimbals—the fourth gimbal is redundant

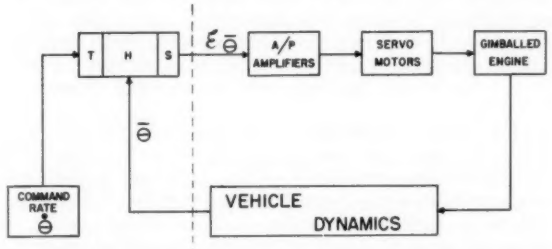
Controllers are used to keep the gyros at operating temperature through built-in heaters. The controllers are all-transistor amplifiers constructed around a half-dozen power transistors, which are used for both power and switching functions because their voltage loss is extremely low. There are no relay contacts in the system, thereby avoiding shock and vibration problems.

At the launching site there is a gyro calibrating equipment for correcting the gyro reference system "memories" for last-minute rocket alignment errors after the rocket is placed on the launching platform.

Line of thrust is controlled by rocket engines in the first and second stages, being manufactured by General Electric and Aero-Jet General. The thrust chambers at the rear of the engines are mounted on gimbal joints and controlled by actuators of the servo system so they can be moved as the rocket is in flight. In flight this will mean, for example, that if the engine thrust pushes the rear of the rocket to the right a few degrees, the nose of the rocket will swing to the left correspondingly. The thrust chambers will change the vehicle heading in pitch and yaw, but off-and-on jets on the sides of the rocket control roll. These auxiliary jets take their commands from the gyro reference systems.

Besides sensing errors in heading and transmitting corrective signals to the autopilot, the system has the third important function of changing the pitch heading of the vehicle into an elliptical trajectory around the earth.

Four factors are important to getting the vehicle in the right position in upper atmosphere so that the third stage may be launched and accelerate the satellite into an orbit around the earth. Velocity, heading, trajectory and altitudes. The system does not concern itself with velocity. All three gyros control heading. However, one-third of the gyro reference system is specifically concerned with trajectory (or pitch angle) and altitude. That one-third is the pitch gyro and its supporting electronic equipment which senses and dictates the arching path for the vehicle. The pitch gyro's "memory" is changed so that it will demand changes in the pitch heading, by a programme timer which feeds a scheduled signal to the pitch gyro's torque generator.



Pitch axis of Vanguard rocket guidance system is illustrated in this simplified block diagram. Changes and corrections needed in pitch axis to guide rocket to satellite-launching orbit are channelled through the autopilot to the servo system that operates actuators which push and pull on the gimballed thrust chamber. Resultant changes in rocket flight dynamics are re-interpreted by pitch gyro to complete closed loop system. In the diagram: H stands for angular momentum of gyro wheel. the property that gives the gyro its "memory". T indicates the gyro torque through which the gyro "memory" is changed. S is the signal pick off. Other figures represent the various angles that must be accounted for in keeping the rocket in the correct pitch heading. $\bar{\theta}$ is the actual pitch angle. $E\bar{\theta}$ is the error in the pitch angle measured by the pitch axis gyro. The error is determined by comparing actual pitch angle ($\bar{\theta}$) to the "memorized" pitch angle. $\dot{\theta}$ represents scheduled changes needed in the pitch angle to allow rocket to slope towards an orbit so that the satellite might be successfully launched

The torque generator—the fourth major component of a floated gyro—is similar in principle to an electromagnet. The programme timer causes a precisely controlled direct current to pass through the torque generator, which produces a small torque to rotate the gyro gimbal to a "new" axis. In a way, the programming process simulates a continual "brain washing" on the pitch gyro.

The change in the pitch direction is so controlled that the rocket makes a gradual turn, and by the time it has reached the launching altitude of approximately 300 miles the third-stage rocket has the right heading so that it can boost the vehicle speed to 18,000 mph along an orbital course before the satellite is separated.

Ultrasonic Metal Cleaning

Very quick preparation of metal for plating and the microscopic cleaning of high precision components without the use of corrosive chemicals

AS development work on the application of ultrasonic agitation to metal finishing proceeds some interesting features and applications are emerging from the mass of spectacular claims and subsequent refutals of recent years. There is little doubt that, with the evolution of new motor-alternators and transducers for the production of the relatively low frequency, high intensity energies now deemed most effective and economical, widespread application of this form of agitation is but a few years away. Already continuous cleaning both of strip metal and of components is practised by several large American, German, and British companies, and the truly amazing increases in both speed and cleaning efficiency on many (although not all) types of article promise greatly expanding applications. Indisputable advantages include the rapid removal of otherwise firmly adherent smuts without special chemicals and the dislodgement of fine particles even when grease-bonded from fissures and pores.

One future application will certainly be in automatic plating machines, disproportionately large parts of which are concerned with cleaning operations. Invariably to some extent, and especially in American machines, generous cleaning facilities to the extent of three or more cleaners, often quite complex solutions withal, are provided to safeguard against either possible failure of a stage or the introduction of unduly soiled work. Given efficient cleansing action based on mechanical rather than chemical or solvent action, a two-stage cycle—possibly solvent followed by mild alkali—and each lasting but a minute or so, may well adequately prepare steel, copper and zinc alloys for plating on the largest scale.

Of interest too are the liquids used in ultrasonically agitated cleaning. Water has found considerable application for removing non-greasy dusts, smuts and fragments; it can be inhibited to prevent the tarnishing of ferrous metals. Among the solvents, in which soils are not only dispersed but grease and oil are dissolved, trichlorethylene has proved one of the most generally suitable; some others, including benzene, have been found to have a suppressing action due to absorption of the ultrasonic energy. Trichlorethylene, however, is not consistent in its cleaning propensity and the reason has lately been traced to its content of dissolved air. It is known that at normal temperatures and pressures it will retain about 18% by volume of air, but the peak cleansing efficiency occurs at about 9%; the problem, therefore, was to obtain trichlorethylene of a standard

Electrochemical Engineering Company Limited

Small ultrasonic cleaning unit with generator, equipped with evacuating plant to eliminate air bubbles

air content. It was solved by pumping the fluid into a vertical tube some 30 ft high. At the top of this was a reservoir and an air-pump by means of which the space above the solvent column could be evacuated. By regulating the degree of vacuum present the amount of aeration could be closely controlled, and a standard product drawn off at the top.

Another development in ultra-sonic cleaning has been the application of a vacuum to the space above the cleaning fluid in order to ensure that no large air-bubbles or air-locks remain in cavities to prevent contact between the fluid and the soil. Tiny air-bubbles in crevices and pores are displaced by the cavitation effect of the sound waves; indeed, they are believed to initiate cavitation. Larger amounts of trapped air, however, prove a problem in all wet finishing operations, but since ultra-sonic cleaning is for the most part at present confined to very small work and loads, the plant is fairly easy to evacuate. The process was developed by Technochemie in Switzerland, specifically for the watch industry where an extremely high standard of cleanliness is essential, and represents the most advanced method to date for cleaning tiny mechanisms. The photograph is of a small unit for cleaning surgical instruments. On a larger scale many applications of this type of equipment can be visualized, one being the oil ducts in internal combustion engines.

The Rotary Kiln

Little of a comprehensive character has been written about rotary kilns, largely because each kiln is usually supplied to meet a particular set of conditions, often unique, so that generalization is difficult. In the following notes, however, an attempt has been made to outline the fundamental basis of kiln construction and application.

ROTARY kilns for the calcining of cement were originally introduced in 1873 by their inventor, the engineer F. Ransom, whose first practical kiln measured 26 ft long by 5 ft dia. It was fuel-fed by producer gas, and proved unsatisfactory until such factors as the calcining period, the rotational speed of the kiln, its angle of inclination, the make-up of the clinker and the lime content, had been more scientifically calculated. Experience in the most satisfactory method of firing was also necessary.

The development of present-day rotary kilns may be gauged from the change in dimensions. Originally from five to six feet diameter by 50 to 60 ft long, they now range from 10 to 14 ft dia by 500 ft long and upwards. The kiln efficiency depends on whether it is operated wet or dry, wet kilns having a thermal efficiency of around 27%, whereas dry kilns operate at 34% or thereabouts. Higher efficiencies than 34% for dry kilns are unusual.

A rotary kiln is essentially a steel shell lined with refractory bricks and revolving at a low speed about an axis slightly inclined to the horizontal. It may be perfectly cylindrical, carry both an enlarged burning zone and a cooler attachment, or comprise a shell and cooler without enlarged burning zone. Rollers support the kiln at two or more points and maintain rolling contact with riding rings, and the kiln is maintained in position by a thrust roller running on the bevelled edge of a thrust riding ring. The shell is caused to revolve by a main or girth gear electrically driven through an enclosed-type gear reducer.

Most rotary kilns are used for producing cement clinker from the raw materials: limestone, clay, shale, blast furnace slag, etc., scientifically mixed, finely ground with or without water, according to the process employed, and then fed to the kiln for calcination. (Of recent years there has been a growing use of rotary kilns for chemical processes other than cement manufacture.) The ground feed is fed into the kiln at the top end and the slow rotation combined with the slope of the shell sends the feed on its way until it emerges eventually as cement clinker, to be cooled and finely ground to cement.

The burning of the mixture is achieved by pulverized coal, fuel oil or gas, which when incandescent is drawn through the kiln hood into the bottom end of the kiln. It first evaporates moisture from the mix at a temperature between 20° and 100° C. The mix contains from 35 to 45% of moisture. This is the wet process. (In the dry process no initial drying is required.)

The dried mix has now to be heated, and for this purpose the air for combustion is also heated by passing it through the hot clinker as it emerges from the kiln. The required temperature when cement clinker is being produced is about 850° C. Cement slurry, however, gives off CO_2 which must be removed completely by a final heating to approximately 1320° to 1340° C.

To produce the final clinker, the temperature of the kiln within the shell is raised to about 1400° to 1450° C. If the kiln has a rotary cooler, the hot clinker passes through this and comes out at a much reduced temperature (about 200° C) and then passes to the tube mills for grinding.

The operator of the kiln is known as the 'kiln burner'. His task is to control the rotation of the kiln, which depends mainly on the angle of inclination, the composition of the slurry and the interior temperature of the kiln. Angle of kiln inclination is expressed as either a percentage (about 2 to 4) or as a gradient (about 1 in 24 or 1 in 48), or again as a fraction of an inch per foot (e.g. $\frac{1}{8}$ in. per ft). The kiln efficiency and design depend on the specific heat of the gases given off, the kinds of solids travelling through it, and the heat of dissociation of the carbonates. There is wide variation in the data discoverable, and extreme caution must be exercised. Kilns are designed for specific functions and *cannot be interchanged at random*, an error into which many have fallen.

Range of kiln speeds is wide. A rotary kiln for agglomerating flue dust revolves at 1 to 2 rpm according to conditions. Another for clinker rotates at 0·59 to 1·76 rpm. Large cement kilns in the United States have averaged 57 revolutions per hour, i.e. about 1 rpm. A rotary kiln for mercury ores runs at 3·5 rpm, while for burning expanded shale aggregates a kiln is reported as operating at 2·0 rpm.

The speed of rotation is believed to be the most important factor in kiln operation. Lowering the speed reduces the temperature of the air for combustion, which in turn delays the ignition of the fuel and causes the burning zone to move up the kiln with the other zones. The kiln gases will be hotter on emergence, and the heat-transmission per unit of kiln length from gases to charge lining will be lower, again raising the gas temperature on discharge. There are other disadvantages caused by too low a rate of kiln rotation.

In the making of cement, the kiln temperature must always exceed theoretical calculations because losses occur in operation. Thus, both discharged gases and clinker are hot in relation to the surrounding air. Heat is lost by radiation from the kiln shell, and too much air is injected into the kiln. The clinkering or fusion temperature is also of great importance. The intensity of the heat is more important than the temperature attained, and this intensity must be kept up or the clinker will be inadequately burned and heat loss will increase.

Length of kiln in relation to diameter cannot be given in the form of a generalization. Data must be obtained from kilns of similar function, and this is not difficult for

cement manufacture; but when the kiln is desired to calcine unusual materials, the only sound method is to analyse the exact chemical modifications that will take place and how they affect temperature. Every factor must be studied or design will be based on wrong data.

Kiln output depends on kiln length and internal diameter, angle of inclination, rate of rotation, condition of interior surface, and flowing characteristics of the slurry or mix. To estimate it in advance, the time occupied by the slurry or mix in passing down the kiln must be estimated. Assuming the kiln has an expanded burning zone carried right to the discharge point, the following formula (Pickering, Feakes and Fitzgerald. "Time for Passage of Material Through Rotary Kilns". *J. Appl. Chem.*, 1.1.1951) can be used:

$$T = \frac{L \sin \theta}{2\pi \, r \, R \sin \alpha}$$

where T = time of passage through kiln, min.
L = length of kiln, ft.
θ = angle of rill of material (i.e., transverse depression of surface below horizontal with kiln running).
r = radius of kiln, ft.
R = revolution per minute of kiln.
α = angle of inclination of kiln.

Most present-day kilns have a variable rate of feed governed by the rate of rotation, and proportional control of both variables is readily achieved by automatic or manual control. For example, the linear rate of travel through the kiln can be altered without changing the depth of the bed. Modification of this linear rate of flow provides constant temperature throughout the kiln.

Some raw materials produce more dust than others, are less plastic, and less capable of forming hard nodules. Limestone and shale mixed are among these. Plasticity is improved by grinding the mix to a higher degree of fineness, but this may demand a greater water content and so necessitate more fuel. Alternatively, bonding reagents can be employed in the mix to reduce dust, but this is costly.

The kiln load in the burning zone must be uniform, or too much dust will be caused, fuel expenses will rise, the output will be of fluctuating quality, the lining and internal parts of the kiln will be more heavily worn, and the kiln will have to close down for repair more often. The raw materials in the kiln should be uniform in each section of the kiln. If the different zones of the kiln are caused to move along its length, they will cause a wave-like load in the burning zone.

Many kilns are supplied with chains in curtains or festoons to improve heat transfer. In such instances the grading of the nodules passing through these chains should be constant or the flow of material through the kiln will be noticeably variable.

The point of major importance is that one factor in kiln operation cannot be changed without corresponding changes in all the other factors, and these changes cannot be worked out in advance by calculation. A few notes on factors to be considered from this point of view will be helpful. Increase in the amount of fuel produces a higher temperature in the discharged gases, gives dryer and more finely graded nodules passing through the chains, increases the rate of flow of material between chains and calcination zone, and so gives a period of higher load in the calcination region. Almost identical effects are caused by increasing the draught of the kiln. If the moisture content of the mix is reduced, the same effects will begin to be felt, but if no further change in the other factors takes place, normal load in the calcination or burning zone will gradually recur after a number of hours.

By cutting down the supply of fuel and the kiln draught or by introducing more water into the slurry, a low load period in the burning zone will be occasioned. Changes in the rate of firing or the volume of feed to the kiln will be indicated by the gas temperature on discharge. It may require a long period of experiment before a correct balance between rise in temperature produced by increase of fuel and fall in temperature occasioned by greater volume of feed can be struck, but this is the only way of ensuring both continuity of operation and the most satisfactory working conditions.

Before 1939 most kilns had enlarged burning zones, because it was believed that as the gases cooled when approaching the top end of the kiln, they required to be confined within a limited space to keep up their efficiency. Nevertheless, the expanded zone makes it more difficult to establish and maintain the lining, while the raw mix occupies smaller space in the bottom end of of the kiln than in the top end. This is because carbon dioxide has been driven off. Consequently there is some compensation for the theoretically lower efficiency, and advocates of the parallel zone are not without arguments, mostly mechanical, to support their views.

Kilns with enlargements for slurry or enlargements close to the feed end facilitate the use of chains, lifters or similar means of transferring heat. These are designed to reduce to a minimum the exit gas temperature while not hampering its flow more than is essential. They are no longer popular, however, because what they do can be done in other ways at a lower upkeep cost and with simpler construction. Longer kilns have been found to minimize fuel consumption and enable the heat of the kiln gases to be used to generate steam by means of waste heat boilers. The longer kiln is less satisfactory for chain efficiency, however, so that some authorities favour an increase in the diameter of the kilns, though this scheme is not widely approved.

The chains and similar heat-transfer appliances generally run from the back end of the kiln to approximately one quarter of its length, being fastened to the shell at one end, the other being loose. The chains are about 4 in. apart and may be single or in pairs, making up a screen of fairly close mesh from one side to the other, with a gap at the free-hanging ends to permit the material to pass through. There are usually from two to six screens suitably spaced in the wet slurry part of the kiln.

Festooned chains are sometimes used. These are fastened to the shell at both ends, but they loop and interweave, having a longitudinal span of about 8 to 10 ft. They run helically along the kiln, and the helix must be specially designed to conform to the rotation of the kiln. They must not be employed in slurry which is no longer moist, or dust will be formed. No more festoons should be employed than will allow the slurry to travel without serious impediment, but there is advantage in using as many as possible. Care must be taken, however, that there is no condensation in ducts and chimneys as a result of drop in rear end temperature.

Heat-exchange fittings must conform to the mix, and usually only one type of raw slurry can be used for a

particular type of heat-exchange fitting. Intelligent application and adequate space for operation is essential for these fittings.

Powdered coal is the most economical firing medium for rotary kilns because of its low cost in many localities, but oil and gas are valuable because they do not affect the slurry composition, can be easily adapted to a regular and continuous flow, and have also constant calorific value and no residual material. If coal is used, it should be as uniform in quality as possible, particularly as regards moisture content, ash formation and generation of gas.

The combustion flame must be at a high temperature (e.g. 1500° C) so that the slurry receives sufficient heat by radiation to make a good clinker. Pulverized coal mingles with the injected air and so kindles swiftly and gives intense heat. The secondary air should be heated before mixture with the powdered coal because this assists in reducing the moisture content of the fuel, which should be as low as possible. The maximum figure is 9·0%, above which there is difficulty in burning because of the larger size of the particles, caused by the difficulty of grinding such wet fuel.

The fuel should have a high content of volatile matter, otherwise it may have to be more finely ground and will not be so readily consumed in the kiln. The ash formation should be low or the clinker may be contaminated and residues build up on the internal walls of the kiln. The rate of air injection into the kiln must not be altered unless the feed rate of the slurry is also altered. The rate of feeding the fuel is primarily a function of the moisture content of the fuel.

Pulverized coal for kiln-firing may be prepared by either the central station or unit system. In the former the coal is pulverized in machines centrally located and is later conveyed to the kiln. In the unit system, the machines are fixed on the kiln firing platforms and the fuel is forced into the kilns by air passing through the pulverizers. Modern plants pulverize to a fineness of 80 to 84% through 200 mesh per lineal inch. Consumption, as a rough guide, is from 22 to 30 tons of standdard coal per 100 tons of clinker, depending on the type of coal. The coal in the central system is ground in tube mills.

The slurry should be fed evenly to the kiln. In the dry process through a spout in which is a screw conveyor; the materials are dry and a water-jacket is placed round the spout. In the wet process a wheel feeder consisting of a wheel with buckets attached is used, being either driven from the kiln shaft or by a variable speed motor. The buckets fall into the storage tank, in which the slurry is kept at a constant level, take up a portion of the mix and feed it at a prescribed rate into the rear end of the kiln by way of a spout. The feed may be varied by altering the rate of rotation of the wheel.

In certain more modern kilns, apron feeders or travelling grates are used, while in others the feed is achieved by pumping the slurry into the kiln. Other modern improvements include slurry filters to remove water from the mix and feed nodules or filter-cake containing about 20% water to the kiln. Most wet kilns also contain slurry lifters, to varying designs, at the top end. These produce a more intimate contact between hot gases and slurry.

The refractory lining of the kiln runs usually over the entire length. The bricks are 9 in. thick in the burning zone to 4½ in. at the cooler end of the kiln. In wet process plants, the upper 25 to 30 ft of kiln length is often left unlined as the slurry keeps this cool. Broadly, a kiln lining should last for at least a year.

Dry process kilns mostly embody pre-heaters which increase the combustion air temperature by transferring the heat of the waste gases to the dry, finely powdered kiln feed. In one type of pre-heater the gases are cleaned in a dust collector and drawn by exhaust fans through cyclone collectors, where they increase the temperature of the raw material suspended in the cyclones after it has been fed in through ducts. The dried and heated material then flows down to the kiln feed spout.

Separate coolers may deal with the hot clinker discharged, but modern practice is to combine cooler and kiln in the same structure. The cooler is an inclined rotary cylinder, about 4 to 10 ft dia by 30 to 100 ft long. It has steel scoops inside it, and as the shell rotates, the hot clinker is continuously lifted and dropped through a flow of air passing through the cooler to the kiln. Thus, the cooler both draws heat from the hot clinker and pre-heats the air for combustion.

No more air than is required for efficient combustion should be introduced into the kiln. Such air may enter with the fuel through the cooler opening, or through the connexion between kiln and hood, or through openings in the hood. All the air for combustion, except what is required for the fuel blast, should be brought through the cooler.

The rotary pressure cooler for precision control of the air intake into the kiln forces the air through the cooler under compression by fan driven by variable speed motor. The tight control of air so given allows a cooler of this type to be used with carbon dioxide and carbon monoxide recorders, facilitating accurate combustion of fuel inside the kiln. The fan deals with cold air alone, and its bearings need not be water-cooled.

Typical processes embodying the use of rotary kilns include calcining cement clinker, calcining lime, agglomeration of fine ores and flue dusts, roasting soda to produce tungsten carbide, aggregation of expanded shale, extraction of zinc from silver ores, calcining mercury ores, calcining titanium oxide, producing sulphur dioxide, making blast furnace slag, manufacturing dolomite and magnesite for refractories, producing gypsum for plaster manufacture, calcining pyrites for sulphuric acid manufacture, and calcination of wolfram, scheelite, titanium lead and other ores.

Precision Drawing on Plastic

Essential qualities for the maintenance of the high standard of accuracy required on projects such as turbine blades, propeller blade forms, etc., is the need for a drafting medium resistant to humidity and temperature change. Entwistle, Thorpe & Company Limited, 21–23 Eagle Street, London WC1, have introduced Replivic, a new plastic sheeting in thicknesses of ·005, ·001, and ·020 in. which is claimed to meet the high standard required. Available either plain or coated (for scribing) the makers are able to supply reproductions on Replivic in a number of forms—straight positive copies, reversed copies (negative from drawn positive or positive from scribed original) sub-masters and negative from negative.

Free-piston Car Engine Development

A review of a prominent American design

THE principle of free-piston engines was thought out by R. Pateras Pescara and was first mainly developed in France. In the early period development was limited to free-piston air compressors and several types were constructed before 1939. In 1941 the firm S.I.G.M.A. (Société Industrielle Générale De Mécanique Appliquée) of Paris, undertook the series production of a 60 hp air compressor. Over 1200 units are today in service in various parts of the world. Since 1937 different types of gas generators have been investigated by SEME (Technical Office for Free Piston Machines). The first free-piston gas generators were built by Alsthom S.A. at Belfort. Later different types were built by various makers and today machines are in use for land and marine electrical generating sets, for ship propulsion, railway traction, for pumping sets and for miscellaneous purposes.

A great contribution to design and practical application in Great Britain and in the Commonwealth was performed by the main licencees, Allan Muntz & Co. Limited of Heston, England. The Muntz type P-42 air compressor, for example, and the GS-34 gasifier engine, performed satisfactorily from the first, and other more efficient designs have been since added. In the United States, the co-operative effort of the Electro-Motive and Cleveland Diesel Divisions of General Motors Corporation, paved the way for rapid advance. In a paper by Gregory Flynn, Jr., from the Mechanical Development Department of General Motors Research Staff is described practical operational experience with free piston units. Results were evalulated from test runs which totalled over 25,000 operational hours of the following units: a Muntz P-42 air compressor; two S.I.G.M.A. units; a General Motors GM-14 gasifier and a GMR 4-4 gasifier of the Hyprex type. The tests run by General Motors Corporation concerned their Siamese Twin unit embodied in the experimental automobile type XP-500, and the power unit became known as GMR-4-4 Hyprex (high pressure and expansion) engine. In the following, General Motors activities with the latter machine are elaborated, based on a paper read by A. F. Underwood in June, 1956, at a Society of Automotive Engineers (S.A.E.) meeting at Atlantic City, N.Y.

The XP-500 free-piston driven car

The G.M.R. 4-4 Hyprex engine

The Hyprex engine was unveiled publicly in May, 1956 at the G.M. Technical Centre at Detroit when the G.M. new 250 horsepower version called XP-500 was presented as an experimental automobile in its early research stage. It has a free-piston gasifier under its bonnet that compresses and pumps air through a 3½-in. pipe to a gas turbine at the rear of the car. Power from the revolving turbine is transmitted to the car wheels. It is notable for its compactness, light weight, improved efficiency and quiet operation.

The gasifier unit is 40 in. long, 34 in. wide and 18 in. high. It has a pair of parallel power cylinders, similar to two-cycle diesel cylinders, each 4 in. dia. The four air compressor pistons, which bounce back and forth in the two cylinders, are each 11 in. dia and have a stroke of about 5 in.

A free-piston-turbine combination has no crankshaft, connecting rods or propeller shaft. What is generally an advantage over the conventional diesel car engine has produced, however, a special problem to car designers. Power for such items as power steering, engine cooling and for other accessories had to be found in a different way from Diesel engine cars.

General Motors experimental gasifier-turbine car XP-500 has no rotating shaft for driving an engine fan, water pump, generator or other accessories, usually driven by a fan belt in a conventional automobile. Instead, a high pressure hydraulic pump is operated from the car rear-end transmission unit. Hydraulic tubes lead to a location under the car bonnet where a hydraulic motor turns the radiator fans and water pump. In practice this system has been very efficient over a wide range of horsepower requirements. Chassis and car body also presented a few problems requiring thought from the designers.

The chassis was specially designed with side frames large enough to house the insulated 3½ in. pipe connecting the gasifier with the turbine, in the near-side frame. The off-side frame is used to house hydraulic power tubing and other lines from rear to front of the car. Because the free piston gasifier under the bonnet has little overall height, the car frame could be stiffened by cross members across the engine compartment.

The styling of the XP-500 body took advantage of the fact that no toe-board transmission hump or propeller shaft tunnel is needed. Thus the middle passenger in the front seat has as comfortable a space to place his feet as the other passengers, and rear seat passengers find a similar advantage.

In comparing XP-500 with today's automobiles, Mr. Underwood listed in his paper some of the major

features of the new combination of a free piston engine and rear-end turbine:

1. Free piston engines are insensitive to fuels, regardless of whether they burn kerosene, No. 2 diesel oil or bunker-C, the cheapest petroleum fuel on the market. They also operate satisfactorily on petrol up to 100 octane.

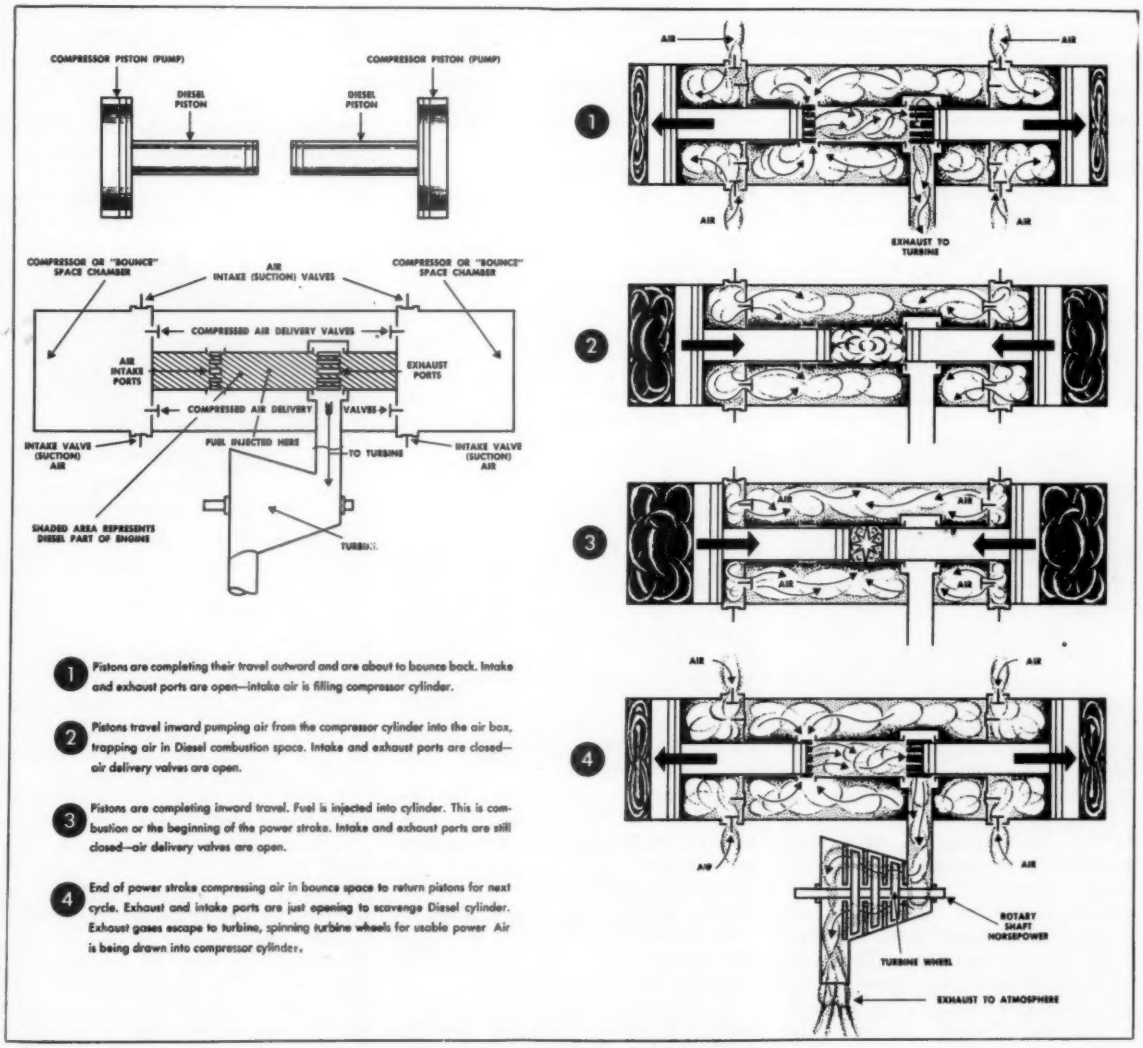
One of the decided advantages is the wide choice of fuel, though it may be premature to predict that the fuel will be independent of any specification (such as octane number). General Motors engineers say that it is certain that the specification can be held to a minimum compared to the requirements of other types of engine.

2. Efficiency of the free-piston-turbine combination is the product of the gas efficiencies of the free-piston gasifier and the turbine. It has been found that the gasifier or air pump section can operate at compression ratios ranging from 30 to 1 up to 50 to 1.

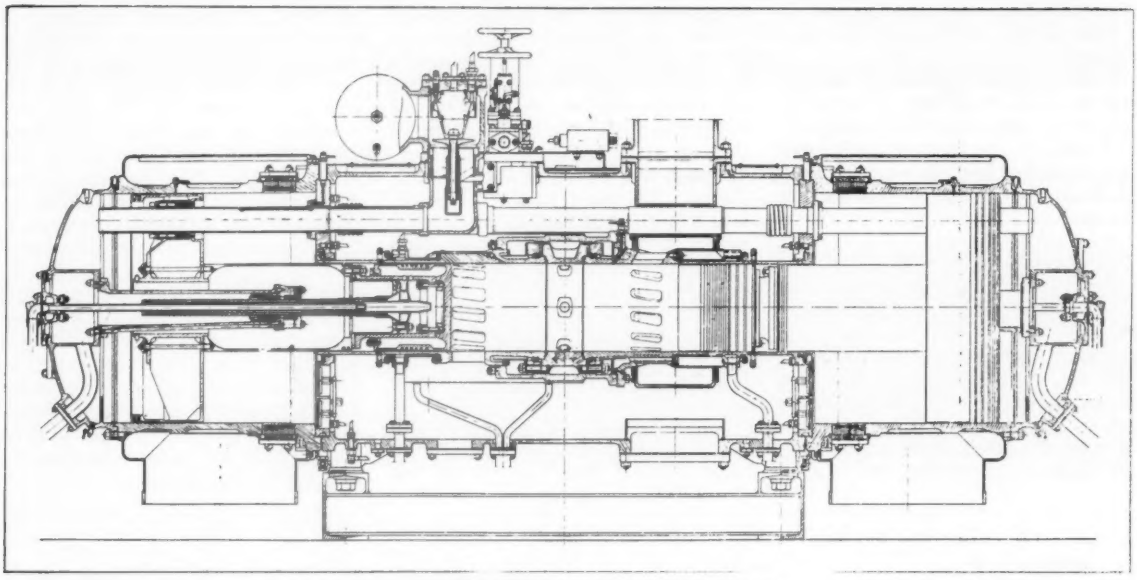
Thus the free-piston has high thermal efficiency rating, meaning that it puts more heat to work. This makes it competitive with the high compression ratio engines and diesel engines of today. Mr. Underwood pointed out in his paper that as far as the customer is concerned, his desire is to obtain the most horsepower-hours for a given amount of money. If, now, the free piston engine uses a cheaper fuel at the same thermal efficiency as a crankshaft engine, then so far as the customer is concerned efficiency is higher when he uses a free-piston engine.

3. Free-piston engines are inherently balanced. It is only necessary to be sure that their major moving parts have exactly the same weight. No special engine mountings are needed to eliminate vibration or torsional movement from spinning flywheels and crankshafts.

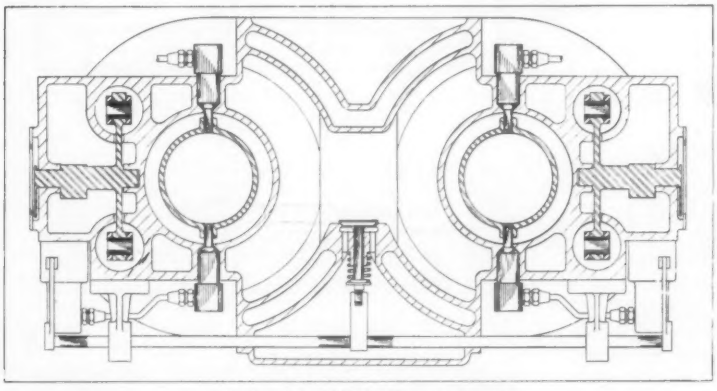
4. The free-piston-turbine combination has good torque in the low-speed range where most of today's driving is done. Thus it appears that only a simple two-speed transmission would be needed for this combination to match the performance of engines with automatic transmissions and torque converters.


COMPRESSOR PISTON (PUMP)
DIESEL PISTON
COMPRESSOR PISTON (PUMP)
DIESEL PISTON
COMPRESSOR OR "BOUNCE" SPACE CHAMBER
AIR INTAKE (SUCTION) VALVES
COMPRESSOR OR "BOUNCE" SPACE CHAMBER
COMPRESSED AIR DELIVERY VALVES
AIR INTAKE PORTS
EXHAUST PORTS
COMPRESSED AIR DELIVERY VALVES
INTAKE VALVE (SUCTION) AIR
FUEL INJECTED HERE
TO TURBINE
INTAKE VALVE (SUCTION) AIR
SHADED AREA REPRESENTS DIESEL PART OF ENGINE
TURBINE
1
AIR
AIR
AIR
AIR
EXHAUST TO TURBINE
2
3
4
AIR
AIR
AIR
AIR
ROTARY SHAFT HORSEPOWER
TURBINE WHEEL
EXHAUST TO ATMOSPHERE
1 Pistons are completing their travel outward and are about to bounce back. Intake and exhaust ports are open—intake air is filling compressor cylinder.
2 Pistons travel inward pumping air from the compressor cylinder into the air box, trapping air in Diesel combustion space. Intake and exhaust ports are closed—air delivery valves are open.
3 Pistons are completing inward travel. Fuel is injected into cylinder. This is combustion or the beginning of the power stroke. Intake and exhaust ports are still closed—air delivery valves are open.
4 End of power stroke compressing air in bounce space to return pistons for next cycle. Exhaust and intake ports are just opening to scavenge Diesel cylinder. Exhaust gases escape to turbine, spinning turbine wheels for usable power. Air is being drawn into compressor cylinder.

Working principle of free-piston gasifier and gas turbine



Cross-section of S.I.G.M.A. gas generator at early stage of design



Section of the GMR 4-4 Hyprex twin engine

5. The free-piston gasifier in the XP-500 pumps low temperature exhaust to the power turbine at the rear of the car, and this results in a number of advantages.

First, the turbine can be made of non-critical materials at moderate cost, as contrasted with automotive gas turbine engines in GM's experimental Firebird II and Turbocruiser, which have to work at high gas temperatures. Another advantage is the ease with which the free-piston gasifier can be connected with the power turbine. In the experimental car the low temperature gas can be readily piped from one part of the vehicle to another. This gives the designer of a free-piston turbine vehicle an independence of location of the gasifier and turbine. The gasifier can be placed where it is most convenient for space and weight considerations and the turbine can be located where the power is to be applied to the wheels. The advantage here is obvious because it is necessary in any conventional car to have a propeller shaft and other mechanical connexion between the engine itself and the final drive.

6. Analysis and design of the experimental XP-500 leads to the conclusion that a free-piston-turbine combination can approach the power-to-weight ratio of today's highly developed petrol engines. The possibility of 3 lb to 5 lb weight per horsepower is very much in the minds of design engineers.

7. Throttle response in any automobile is highly desirable, and the free-piston gasifier makes its power available quickly to the rear wheels. The gasifier rapidly increases its gas output to the turbine. On the other hand, deceleration or slowing down is just as rapid because the pistons stop at the end of each stroke, and there is no flywheel effect in any element of the gasifier.

Outside view of the GMR 4-4 Hyprex engine—a concept of the free-piston engine for automotive use

8. The speaker also discussed the possibility of an after burner in XP-500's power package. This could be placed between the gasifier and turbine, and additional fuel could be burned to supply more power to the turbine, making additional power available instantaneously.

9. The free piston engine offers a basic "building block" for a whole family of engines with virtually the same components, starting with a single-cylinder design. Next is a Siamese or two-cylinder design, and higher horsepower would be developed by two or more units feeding into a common header to the power turbine. In this manner all engines would be serviceable from one set of parts, especially

those parts that would need replacement.

This feature, Mr. Underwood declared, brings the free-piston engine into the situation enjoyed by gasoline and diesel engines where the same components can be used for several engines. Producing such a family of engines is attractive because it can be done on tools similar to present crankshaft engines.

In conclusion it should be stated that General Motors executives and engineers are optimistic about future developments, and three of their specialist engineers have repeated this outlook recently. They expect improvements in design to make gas turbines more efficient, and cheaper to build. They intend to give special consideration to radial in-flow types and to turbines of the positive displacement design. The advantages of the comparatively low exhaust temperature from the free-piston gasifier allow for experiments to be carried out which the more conventional gas turbine car cannot provide. A decrease in fuel-to-horsepower rate better than 0·36 lb per gas hp-hr is also within reach by improved combustion and efficiency in the gasifier section.

Bibliography

A. F. Underwood. "The GMR. 4-4 'Hyprex' Engine—A Concept of the Free Piston Engine for Automotive Uses." Paper read before the Society of Automotive Engineers, Inc. 29 West 39th Street, N.Y.18.

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Screw Thread Comparator

Repetitive thread measuring to within ·0005 in. is claimed for the Marlco screw thread comparator made by W. H. Marley & Company Limited, 105 High Road, New Southgate, London N11. Based on the same principle as the Marlco thread measuring parallels, but employing a dial indicator instead of a micrometer, the instrument has a capacity of 0–2½ in.

The required anvils are inserted in the holders, and are retained in axial position against a hardened ball by internal circlips. This permits rotation of the anvils to accommodate the various helix angles when measuring the effective diameter of threads. The gap is roughly set to accommodate the component and the back-stop adjusted to register it in the desired position. Final setting on the dial indicator to a zero reading is made

Marlco thread comparator for measuring effective diameters of threads up to 2½ in.

by the fine screw adjustment through the lower anvil holder. The trigger mechanism to the dial indicator which permits engagement of the component in position before lowering the anvil is finger controlled.

The instrument is supplied with one flat and one hemispherical anvil, to enable the comparator to be used for plain diameter work. A stand is also available, which holds the instrument at an angle to permit easy viewing of the dial indicator.

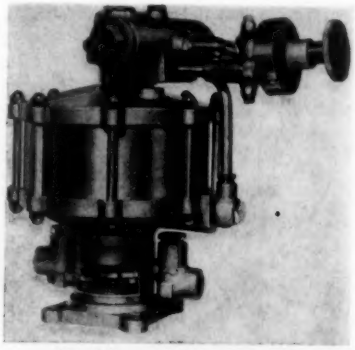
Each pair of thread measuring anvils covers a range of threads of a given form. The Whitworth set (4½–40 tpi) can be used on any 55° thread form, including B.S.F. and B.S.P., irrespective of direction of thread. This also applies to the U.S. and Unified sets each of which covers 4–44 tpi, metric, covering 6·0 to 0·5 mm pitch, and B.A. covering 0–6 B.A.

New Models Complete the Airhydropump Range

An intermediate range of Airhydro-pumps, the well-known compressed air-operated hydraulic pumps manufactured by Charles S. Madan & Company Limited, Vortex Works, Altrincham, Cheshire, has been developed to fill the gap between their existing models.

The new design, known as the Airhydro Power Unit, is available in nine sizes covering a hydraulic pressure range from 62 to 22,500 psi from a normal compressed air supply of not more than 100 psi. The weights of the complete units vary from 50 to 80 lb, all models being 12 in. high, and overall diameters vary from 7½ to 12 in. depending on ratio. The particular model in our illustration has a ratio of 1:21·3 and is capable of developing a maximum static pressure of 2100 psi with 100 psi air. The air reducing and control valve enables intermediate pressures within the range of each model to be obtained.

An important feature of these pumps is their ability to maintain a static pressure indefinitely without consuming any air. If the balance is disturbed through a leak or a movement in the power loaded machine, the pump will automatically move sufficiently to maintain the hydraulic pressure required. The consumption of compressed air is, in any case, limited in proportion to the amount of hydraulic fluid being delivered by



One of the new Airhydro power units

the pump. Materials used throughout are non-ferrous or stainless steel, and the air and hydraulic packings are of the fabric reinforced synthetic rubber type. These are suitable for water, kerosene and the majority of hydraulic fluids in regular use, but for corrosive liquids seals of special quality can be fitted.

Manufacturing the Herbert-DeVlieg No. 2B-36 Spiramatic Jigmil

Production to a general assembly accuracy of .0001 in. per ft with specially-equipped plant at the Lutterworth works of Alfred Herbert Limited

The British-made Herbert-DeVlieg No. 2B-36 Spiramatic Jigmil

FOR the past ten years Alfred Herbert Limited of Coventry have been acting as sole distributors in this country for the Spiramatic Jigmils developed by the DeVlieg Machine Company of Detroit, U.S.A., but now, in the new 16,500 sq ft extensions at their Lutterworth Works the smallest of the range is being manufactured under license and will be known as the Herbert-DeVlieg No. 2B-36 Jigmil. It is built to a general assembly accuracy of ·0001 in. per ft. and apart from minor exceptions, is an exact copy of the American-made machine to ensure interchangeability between components for both manufactures. The Unified thread system is used throughout manufacture and DeVlieg standards are adopted for such components as splined shafts.

The main purpose of the DeVlieg Jigmil is precision boring and milling without the use of jigs. The Jigmil principle permits up to four sides (more if the workpiece is mounted on a circular table) to be approached at one setting. Thus the angular relationship between milled surfaces, bores and drilled, reamed, counterbored and tapped holes can be held to the same precise limits as obtained in hole diameters and spacing.

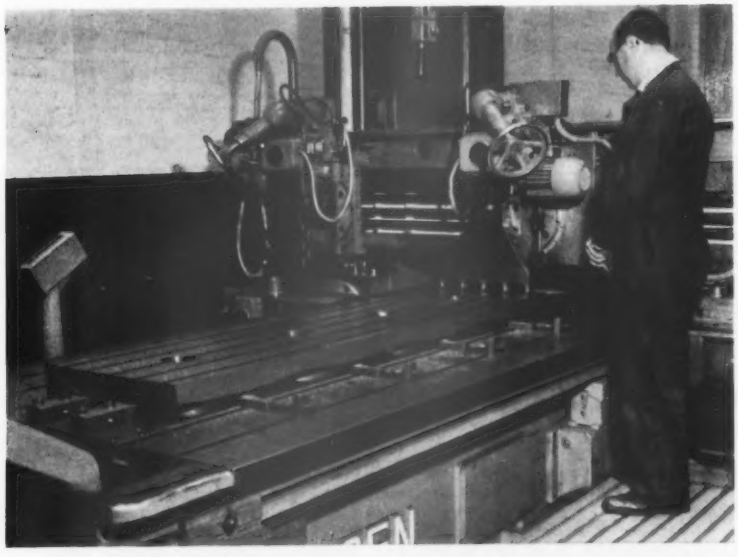


Fig. 1. Precision machining the T-slots in a gang of index tables on the Waldrich-Siegen planing machine. Three sets of Ardoloy buttons of different diameters provide multiple cutting edges and the shanks are a push fit in the tool block. Tolerance .0001 in. Note the elimination of clamps to avoid stress

The 2B-36 Jigmil is fitted with a 36 × 24 in. T-slotted table having a cross travel of 12 in. and the movement of the saddle on the bed slideways is 36 in. The vertical travel of the spindle head on the column is 24 in. The system of positioning the machine table and spindle head in the horizontal and vertical planes is carried out automatically through a patented sequenced electrical cycle. This feature provides a means for controlling hole spacing in the workpiece to precise limits of accuracy through the simple operation of a push button.

Appropriate end-measuring gauges or Duplitrol bars are placed in position in the measuring troughs on the spindle column and machine table. A button pressed to start the cycle causes the machine table or spindle head to move by rapid traverse until the end-measuring gauge contacts the arm projecting from an automatic positioning unit. The cycle is then completed by the oscillation of the table and spindle head about the zero line at successively slower feeds and eventually stopping in the position

Fig. 2. (left): Attachment fitted to a Herbert drilling machine for drilling at right-angles, holes in internal faces, webs and cross bracings. In this photograph, an oil hole in the spindle head bearing housing is being drilled

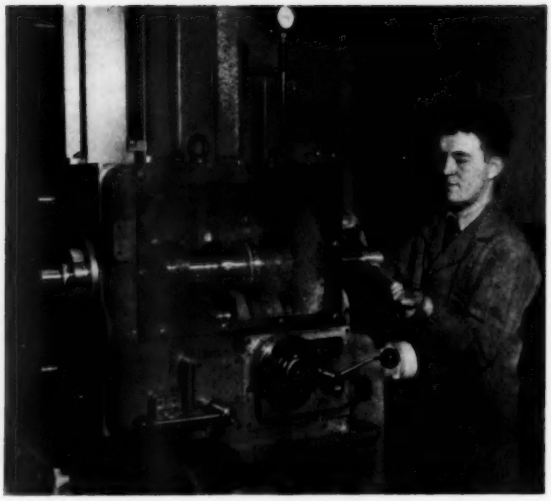


Fig. 4. (right): Lapping nitraloy spindle sleeve bushing, whilst the spindle is running to a tolerance of .00015/.0002 in. relative to the size of the spindle to be fitted

determined by the gauges or Duplitrol bars. At the final location position the machine automatically releases the end thrust of the feed screw so that the table or spindle head can be locked securely without affecting their accurate location.

The cross travel of the table is fully automatic for ease of tool changing and work inspection, with automatic repositioning and locking by push-button control. A circular scale and micrometer dial give a 12 in. adjustment of the locking position of table front relative to the spindle flange.

The 2½ in. dia spindle bar having a 12 in. travel is driven by a 5 hp, 1500 rpm motor through helical gears in constant mesh. The standard 16 spindle speeds ranging from 42 to 2000 rpm or the alternative higher speed range of 50 to 2400 rpm which can be provided if desired are selected by a dial on the head and operated by a lever. To ensure full engagement of the clutches in the head the spindle runs at slow speed prior to automatic engagement of the pre-selected speed. Six bar feeds from ·0016 to ·018 in./rpm are available, and for single depth or back facing operations dials and vernier can be set to disengage automatically the power bar feed mechanism at any depth up to 12 in. For multiple operations a rotating indexing turret fitted with adjustable stops and trip unit can be supplied. The spindle nose is taper bored No. 40 N.M.T.B. and by the use of a power-operated draw bar with push-button control, tools can be rapidly locked with uniform pressure at any position within the travel of the boring bar. Sixteen feeds for milling ranging from 0·4 to 32 in./min can be applied to the saddle and spindle head and two rates of traverse, 50 and 150 in./min.

In the manufacture of the Jigmil at Lutterworth Alfred Herbert Limited have embodied the underlying purpose of the product itself, namely highly accurate machining with the minimum of special tooling. A practical demonstration of this policy is the use of DeVlieg 2B-36 and 4B-60 Jigmils for precision boring of all the castings and certain milling operations without jigs—

Fig. 3. Vertical broaching machine equipped with power retriever for broaching components such as involute splines in sliding clutches

proof enough of the machine's capabilities.

Production commences with the stress relieving of all major castings, entailing a 23 hr treatment in a large capacity oil-fired furnace built by Gibbons Bros., Limited, Dudley. The initial temperature of 600° F is increased over a 9 hr period at a rate of 50° F per hour up to a maximum of 1050° F. This temperature is maintained for 5 hr before reducing at similar rate over the next 9 hr down to the initial temperature. To ensure that stresses are not re-introduced clamping of the component in subsequent machining operations is kept to a minimum. Stresses set up by heavy metal removal are also avoided, the extended machining times invariably being offset by the time saved in scraping and fitting. A Swift Summerskill 12 ft × 4 ft 6 in. × 4 ft planer is used for rough machining operations. All finish planing operations on the beds, columns, work tables and indexing tables are performed on a Waldrich-Siegen 10 ft machine which is capable of planing to an accuracy of ·0001 in. per ft. In Fig. 1 a multi-tool holder is being used to machine the T-slots of the indexing table simultaneously to a tolerance of ·0001 in. on squareness and parallelism. All five slots in the table are held to this degree of accuracy by the use of three sets of progressive diameter Ardoloy button tools for the final cut. Each tool shank is a push fit in the tool block. The tool head is mounted on a vertical slide fitted with motorized drive so that at the end of each

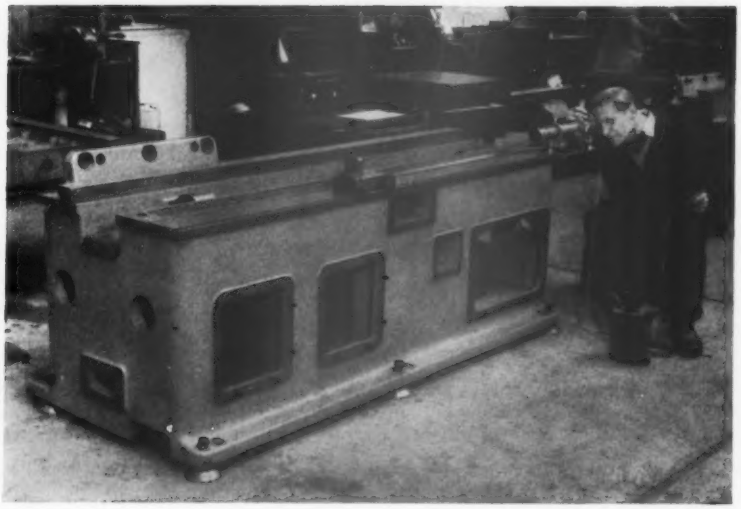


Fig. 5. (left): Using an auto-collimator for a final check on accuracy of bed and column ways before erection

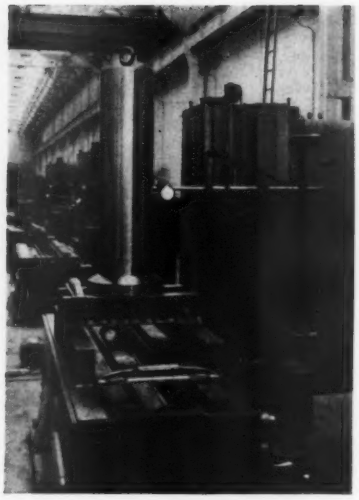


Fig. 6. (right): Determining squareness of the column ways to the bedways. This inspection is carried out before and subsequent to the drilling, reaming and dowelling of the bed to the column

cutting stroke the tools are raised clear of the work during the return stroke. As already mentioned boring operations on all castings are performed on DeVlieg Jigmils. The feed gearbox, for instance is produced in two parts—each is bored separately and then bolted together —the dowel holes being produced at the same time as the bores. This procedure saves time and eliminates the need for long and complex boring bars with their attendant difficulties of tool setting and bar flexing, a method of production however, dependent on the inherent accuracy of the Jigmil itself. The 4B Jigmil is used for milling the lead screw nut guide channels on the upper side of the saddle and various tenon slots and also for boring the locating holes in the index tables. Of the few special-purpose machines the DeVlieg tap-broaching machine is noteworthy having been specially designed to ensure the accuracy of the lead screw nuts. Leader controlled Herbert ground thread taps hold size and thread form to extremely close limits in all elements. Another special-purpose machine, in this case a Herbert-built machine for horizontal drilling, reaming, tapping, counterboring and spot facing is shown in Fig. 2. In the illustration an attachment for drilling at right angles, in internal faces, etc., is being used for the oil holes in the spindle head bearing housing. A vertical broaching machine, Fig. 3, equipped with power retriever is used for broaching numerous components such as the involute splines in the sliding clutches.

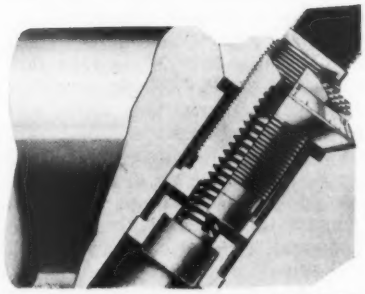
All gears are produced on a British-built Herbert/Fellows No. 7125A gear shaper; some being subsequently induction heat treated and the majority shaved on a Churchill-Red Ring shaver. All the spindle driving gears are helical and are checked on a Orcutt lead measuring machine which incorporates a Taylor-Hobson Talymin gauge head with rectilinear recording unit and amplifier. In the sub-assembly section equipment includes a deep-freeze unit and a hot oil bath for fitting bearings on shafts. Final lapping of the nitraloy spindle sleeve bushing is performed by hand whilst the spindle is running, Fig. 4, to a tolerance of ·00015 to ·0002 in. relative to the size of spindle to be fitted.

In the erection bay 14 specially prepared reinforced concrete foundations have been installed to ensure absolute freedom from vibration during assembly, alignment, setting and testing. Each foundation base measuring 15 ft 5 in. × 14 ft 7 in. is carried on nine pillars 7 ft deep. The first four foundations are used during the scraping of bedways, the others for progressive assembly and checking. Final checking of the column and bedways is by means of an auto-collimator, Fig. 5. A master cylinder is used to check the squareness of the column ways to the bedways, Fig. 6. This inspection is carried before and after the drilling, reaming and dowelling of the bed to the column.

All electrical control gear for the Jigmil is housed in a cabinet attached to the machine. A specially-built test rig is employed for checking all electrical functions before the cabinet is finally fitted.

Production of the Microbore Precision Cutting Tool Unit

Adjacent to the production lines for the Jigmil, Alfred Herbert Limited have introduced a new section for the production of Microbore tools. Though originally developed for performing precision boring on the DeVlieg Jigmil machines these single point cutting tools are now being widely used on capstan and turret lathes, automatic chucking machines for turning, plunge facing chamfering, etc., and for precision operations in horizontal and vertical boring machines. The



Section showing Microbore unit mounted in a boring bar

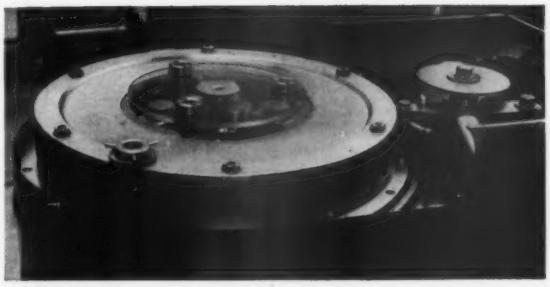


Fig. 8. (above): The cartridge is thread rolled on a machine equipped with three rolls which ensures concentric thread diameters. Automatic ejection is provided

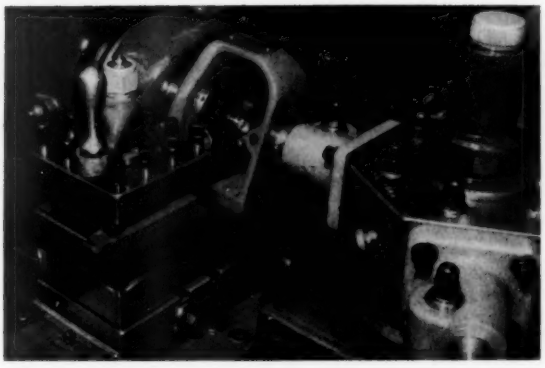


Fig. 9. (right): The polygon box included in the lathe set-ups on the Herbert No. 2D and 4 capstan lathes, for producing the four flats on the Microbore dial

assembly of the Microbore unit mounted in boring bar is shown in Fig. 7.

Previously the Microbore cartridge was turned from bar and threaded in one operation on capstan lathes, but with clamping and locating in subsequent operations the thread was liable to be damaged. The new sequence of operations for machining the cartridge is as follows:

1. Machine cartridge from bar on Herbert Nos. 2D, 3 and 4 capstan lathes.
2. Centreless grind the thread diameter to size.
3. Forming the ears on the cartridge using a Mills Oilaulic press.
4. Mill the seating for the Ardoloy tip.
5. Roll-engrave the tip grade identification.
6. Induction brazing of the tip.
7. Vapour blast.
8. Thread rolling on a machine equipped with three rolls to ensure concentric thread diameters (Fig. 8).
9. Grind and lap the tip.

The dials are machined from bar either on Herbert Nos. 2D or 4 capstan lathes. Included in the lathe set-up on these machines is a polygon box shown in Fig. 9 for producing the four flats on the dial. The dial graduations are roll engraved before parting-off. For grinding the cone the dial is screwed on a master mandrel to ensure concentricity.

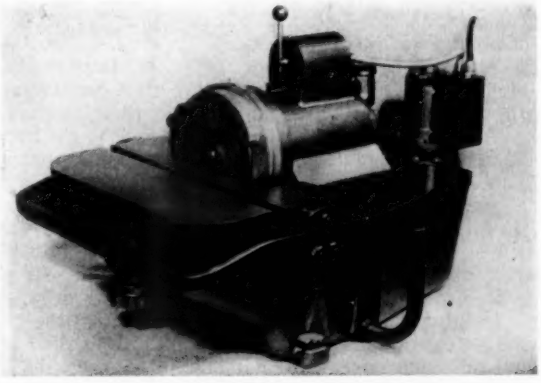
A recent installation is a new type of tool grinding machine for semi-automatically grinding an accurate tool profile. This machine, developed by the DeVlieg company, enables a very accurate radius blended with the cutting edges and relative to the clearance angles, to be ground. It is also possible to grind either conical or cylindrical radii by offsetting the axis of the work-holding arrangement.

Inspection is made on a Hilger Universal projector.

Oscillating Lapping Machine for Carbide Tools

A lapping machine with an oscillating head has been designed for tungsten carbide tool lapping using diamond impregnated wheels. The advantages claimed for the oscillating motion are the ease with which a perfectly straight edge can be produced with complete freedom from facets on the cutting edge and fuller utilization of the wheel surface. Both left- and right-hand lathe tools of large section can be lapped with equal efficiency as the machine has a reversible guard which will accept tools $1\frac{3}{4}$ in. high.

The machine is designed by Impregnated Diamond Products Limited, Gloucester to operate with a Neven 6 in. dia wheel having either a $\frac{3}{4}$ or $\frac{5}{8}$ in. wide impregnated rim. The standard grade supplied is a Neven medium 120/160 but due to the method of operation it is ideally suited for the use of superfine grade wheels for obtaining a mirror finish, and a finish of approximately $\frac{1}{2}$ microinch can be obtained on a tungsten carbide tip. The drive is direct, the wheel mounting flange being fitted with a taper on to the end of the motor spindle. The 1 hp motor available for 400/440 V, 3 phase, 50 or 60 cycle, or 200/220 V, 3 phase, 50 or 60 cycle, runs at 2850 rpm. The winding is to B.S. 170 specification with Class A insulation and mica between phases to allow the motor to be reversed at will without any fear of damaging the windings. The hinged table measures $16\frac{3}{4}$ in. $\times$ 8 in. and is adjustable for rake from $+5°$ to $-15°$, adjustment being by means of a micro screw



G.F—O bench type oscillating grinding and lapping machine

readily accessible under the front of the base of the machine. The table also incorporates a tenon slot ·625 in. wide $\times$ ·320 in. deep for fitting a protractor if required. The base which forms the coolant tank is of heavy construction to eliminate vibration.

The oscillating motion of 30 strokes per minute is produced by a separate small motor situated at the rear of the machine. This operates through a gear box and adjustment is available to vary the length of the oscillating stroke to a maximum of $\frac{5}{8}$ in. on either side of the centre line. A cut out switch is fitted should the operator wish to grind without the oscillating motion.

technique

devoted to the discussion of practical problems. Readers are invited to contribute items from their own experience in matters relating to design, manufacture and maintenance. Payment will be made for published contributions.

Any Questions ? We welcome inquiries concerning difficulties arising out of our readers' general work, for treatment in the **technique** section. The full name and address of the writer (not necessarily for publication) must accompany each communication

Welding in Oil Refinery Construction

At the Kent refinery of the British Petroleum Company Limited, extensions are now being built at an estimated cost of £30,000,000 which will increase capacity by about 2½ million tons of oil per year.

All welding being carried out on the site must achieve the highest standard, not only because of the high temperatures and pressures used at many points in the refinery, but also because a fault in even a low pressure, low temperature line can have serious effect on production and may also produce fire hazards. In view of this, all welders must undergo stringent tests in all types of work they are to perform before they commence to operate on the site.

Erection of tankage on the site is being handled by the Motherwell Bridge and Engineering Company Limited. A large proportion of the circumferential welding of tanks is being carried out with the aid of two Quasi-Arc Pandjiris girth welders.

This machine consists of two Unionmelt D.S.H. welding heads with control panels and platforms for the two operators. These are mounted on a saddle-type carriage which straddles the upper strake of the joint which is to be welded.

The drive and idler wheels of the carriage run directly on the curved edge of the plate, and guide rolls are provided to act as a pivoting device. In addition eight rubber tyred stabilizer castor wheels are provided, four on each side, to maintain stability of the machine in operation. These are adjustable and retractable for setting-up purposes.

Thus, there is one welding head inside the vessel and one outside, with an operator on the platform of each. As the carriage moves at the selected welding speed round the perimeter of the tank, the internal and external seams are welded simultaneously and continuously in the horizontal position.

Vertical adjustment for the welding head allows for plate widths from 4 ft to 9 ft, with additional adjustment of 12 in. for fine adjustment of the welding heads. A spot-light guiding device is also fitted to enable the operator to guide the welding nozzle accurately along the joint. The carriage movement is remotely controlled from the operator's control panels, and speed indicators are fitted.

Oxy-acetylene or propane-compressed-air pre-heat torches are fitted ahead of the welding nozzles to ensure that plates are completely dry for welding. When oxy-acetylene gas is used, stowages for the gas bottles are fitted to the machine when required. Telephone sets for constant communication between operators are also provided.

The Unionmelt welding composition in this installation is supported under the welding nozzles by endless belts, tilted so that composition presses against the joint. Support is thus provided for the molten weld metal so that welding current up to 750 amps can be used. A continuous melt circulation system recovers the unfused composition and feeds it back to the hopper at the top of the machine, whence it falls back by gravity to the welding nozzles.

To obtain maximum economy, the duty cycle of the machine must be as high as possible. For this reason, procedures have been worked out for welding groups of tanks which ensure that the girth welder is idle for as little time as possible.

The use of automatic welding of tanks cuts down plate preparation time as well as welding time. All plate thicknesses up to $\frac{9}{32}$ in. can be welded without any edge preparation. Thicker plates are prepared with a 45° double bevel and a $\frac{1}{8}$ in. root face on the upper plate. The consumables used in tank welding are $\frac{3}{32}$ in., $\frac{1}{8}$ in., and $\frac{5}{32}$ in. Unionmelt wire and 50 grade 8×48 Unionmelt powder.

The thickness of the plate used in a tank often decreases with the height. Since the inside of a tank remains flush, all stepping is therefore on the outside, and this may necessitate the deposition of more weld metal on the outside than on the inside. When this is so, it is usual to use thicker wire on the outside.

Refinery plant at the Isle of Grain is being erected by George Wimpey and Company Limited. To provide welding power sources, the firm is using a total of 75 Quasi-Arc MCR 375 rectifier sets. The MCR 375 has no constantly moving parts except the cooling fan, and has an extremely low no-load consumption. In site work, where frequent interruptions of the arc are often unavoidable, this can lead to considerable economies in power consumption. The transformer incorporated in the rectifier is designed to impose a balanced load on the power supply. Current control is effected by a moving coil reactor which gives stepless control of the output over the full current range from 30 to 375 amp, and a centrifugal switch is incorporated which disconnects the equipment from the supply in the event of fan failure. The machines are used to supply current for manual welding, with E6010, E6012, E6013 and stainless electrodes.

Two Sigma machines for mild steel welding on distillation columns have been installed. One of the columns is 22 ft dia and 120 ft high, the other being 20 ft dia and 150 ft high. Trays, with their associated internal fittings and downcomers, are fitted at intervals; one column having nine trays, and the other twenty-nine.

The outside diameter of the trays is smaller than the inside diameter of the towers, and an annular distance-piece separates the two. The problem was to weld the distance piece to the tower wall, and also the tray to the distance-piece. Two fillet welds of approximately ¼ in. leg length were required. The first part of the work was carried out by the manual covered electrode process, but it was then decided that the Sigma process with its inherently fast deposition rate should be used.

Very long uninterrupted welds were to be deposited under sheltered

conditions where work was unlikely to break off due to adverse weather. In these circumstances, the fact that no pause is necessary to change electrodes and also no slag to remove has resulted in a high arcing time. Production of the towers was speeded considerably and labour costs and over-heads were reduced.

The Sigma process was also valuable in view of the difficulty of manipulating an 18 in. electrode with its holder in the confined space between trays. Welders also found difficulty in contending with fumes produced by manual electrodes, and the use of fume extracting apparatus increased congestion especially at the manholes. The Sigma pistol, which is water cooled, can be manipulated more easily in a confined space than a normal electrode; and less fume is evolved than from a covered electrode.

The deposition of $\frac{3}{4}$ in. fillet welds over such a large footage entails the use of very large quantities of filler metal. It is esimated that approximately one ton of mild steel 65 wire will have been deposited by the time the towers are completed. The wire has been specially developed for the Sigma process. Its analysis is C 0.06% max., Mo 1%–1.4%, P 0.03% max., S 0.03% max., Si 0.4%–0.6%, Al 0.02%–0.12%, Zi 0.02%–0.12%, Ti 0.02%–0.12%, and it is deposited under a shielding envelope of argon with the addition of 5% oxygen.

Among the constructions undertaken by George Wimpey which call for especially high weld quality are the two hydrofiners which work at pressures up to 1000 psi. The headers for these are in 18/8/1 stainless steel of $\frac{5}{8}$ in. thickness and are 6 in. dia. They are welded to tubes of the same diameter with wall thicknesses of $\frac{3}{4}$ in. or $\frac{5}{16}$ in.

The root run is carried out by the Argonarc process, using a consumable backing ring. The subsequent runs are carried out by metal arc welding with 18/8/1 covered electrodes. Quasi-Arc Chromoid No. 2 electrodes of special analysis to meet B.P. requirements for ferrite content are used in this work.

George Wimpey are also handling a large amount of pipe-work. A typical example is a 24 in. dia transmission pipe, which is welded to the "double-ended" sequence using Celtian electrodes with a downward technique for the root run. These are cellulose type electrodes to AWS/ASTM classification E6010 (B.S. 1719: 1951, E110) but in this sphere of electrode production they represent a new departure.

The addition of iron powder to the coverings confers considerable advantages in welding performance and makes it possible to deposit increased lengths of run per electrode, or alternatively to deposit a larger unit volume of weld metal in the same welding time as for normal cellulose covered electrodes.

A variation of the normal "stove-pipe" technique is used, in which the welder travels back over "windows" immediately they are formed, instead of leaving them to the next pass. In fact, few "windows" are produced with this new type of E6010 electrode, and with the technique adopted, only the root pass is necessary to give adequate support for the automatic passes subsequently added to complete the joint. The automatic welding is performed by a fixed welding head while the pipe sections are rotated at welding speed on a roller bed. The extension scheme at the refinery, which includes a plant which can produce 130,000 tons of aviation gasoline per year, will raise output to meet growing demands in both Britain and North-West Europe.

Gear Cutting Fixture for Upstroke Cutting

Fixtures for gear cutting are seldom difficult to devise but occasionally there occurs a component where the orthodox down cutting is impossible and resort has to be made to cutting away from the fixture in what is normally regarded in other work as unsound practice. However, by using a steady such operations are feasible and give excellent results.

Fig. 1 illustrates a component which has two gears at one end of a shaft. The gears are of nearly the same diameter but are of different diametral pitch so the numbers of teeth are different. Clamping the shaft requires a single location. It

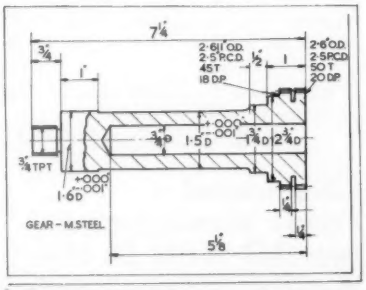


Fig. 1. Component with two gears of different D.P. close together, making it necessary to cut them from opposite directions

cannot be reversed to allow down cutting of each gear separately, thus a common location is necessary which means that one wheel is beneath the other and therefore makes up cutting essential.

The fixture, Fig. 2, consists of a base A fitting into the rotating table of the gear cutting machine, and bored to receive the split bush B which is tapered to fit both the base and clamping cap C. The action of the clamp is to cause the bush to hold the shaft securely after the manner of

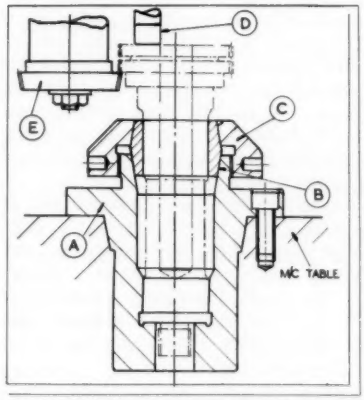


Fig. 2. The fixture is set well down into the gear cutting machine table but the part stands fairly high to give the cutter ample clearance

a collet chuck. As an additional location the lower end of the base is bored to suit the component diameter near the threaded end, and at the same time cutter thrust is taken by the shoulder at that end on the lower portion of the base.

The shaft protrudes sufficiently above the fixture cap to ensure adequate cutter clearance. It has to be remembered that there is a nut fastening the cutter which has sometimes to be allowed for; in the present case it is clear of the fixture.

Upstroking can cause a shaft to lift unless precautions are taken to hold it securely, done here by the machine steady foot D. This bears down on the workpiece and while allowing the gear to rotate, presents the action of the cutter disturbing the shaft. A batch of parts is cut in this direction, then the cutter is changed, the stroke re-adjusted and work commences on the other blank diameter. If position gears are needed (gears where the tooth or

space on one member is positioned correctly with that on the other) this is feasible by adding a setting piece to the base and offering the cutter to it before cutting the second gear. Such a plate is fairly easily set on the flange of the base but is often only temporarily attached as the cutter would normally strike it during the downward movement.

The lower location diameter is an excellent feature as it imparts a steadying effect to the shaft usually found impossible by clamping the upper diameter.

If a range of parts is required the provision of bushes instead of a solid base makes it possible to cut different sizes on a single fixture, thus saving tool costs. With all equipment of this type, case-hardening is essential for long service.

Improved Threading Fixture

The threading fixture which dispenses with the aid of a clamp, described on page 123 of the March issue of MECHANICAL WORLD is not so simple and inexpensive as it looks. The writer speaks as though a few pieces of material were just stuck together and at the same time highlights the importance of quality and quantity of production, which stems from proper selection. This is true, but in this case these ends could have been furthered by more thought being applied, coupled of course with greater experience.

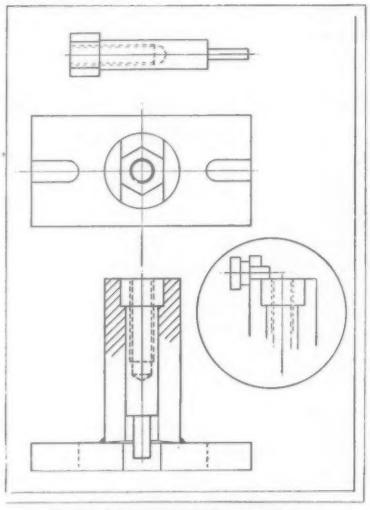
Considering the fixture as it stands, is the hexagonal hole necessary? A slot milled in the lower plate would have sufficed. Better swarf clearance would have been provided, and machining a slot is far easier than producing a hexagonal hole.

Secondly the whole thing could have been made of two pieces of material instead of five, to a design which would have embodied a fundamental workshop principle, i.e., the reference square, which should be well known. The suggested design is shown in the accompanying sketch. Here the column which locates the component to be tapped can easily be produced with its internal locating diameters at right angles to the base, which should have slight convexity. The slot locating the hexagon is milled central with the bore. Although accuracy here is not important, centrality of the slot is readily achieved by boring a recess during the turning operation to the depth of the slot; the diameter being the width across the flats. The column is then carefully welded to the base plate through which a hole has been bored for swarf clearance. It will be noted that only one diameter has been used for location.

It would appear from the component sketch that this is all that is necessary. It should also be noted that some tapping heads require to act against a keep plate before reversal can be effected. This could be readily provided for as shown in the scrap view.

With such a design as this the accuracy is never in doubt.—

H. B. Miles, Grad.I.Mech.E.



Design for improved threading fixture

Increased Wear Resistance for Oil Well Drills

In drilling for oil it is usual to reach depths of 5000 or 10,000 ft, the depth being dependent upon the rock formation and up to 20,000 ft of rock may have to be drilled before the oil vein is discovered.

Each cutter is used up to the point of destruction and it is essential that it should be able to withstand the maximum amount of abrasion. Hughes Tool Company Limited are using the atomic hydrogen welding process in the manufacture of their Tri-Cone rock bits at their factory at Castlereagh, Belfast, where they make 144 different sizes and types of rock bits with diameters ranging from 4¼ in. to 12¼ in. Each rock bit consists of three sections welded together. In view of the great amount of abrasion on the cutters, the teeth of each cone must be hard-faced to increase wear resistance. The teeth are hard-faced one at a time and great localized heat is necessary.

The hard-facing operation is carried out with the aid of a mild steel tube filled with tungsten carbide granules. In the atomic hydrogen welding process, hydrogen is passed through an arc to provide a source of heat which melts the hard-facing tube. British Oxygen Gases Limited furnish hydrogen in large cylinders and the gas is piped from the cylinders to the welding stations.

Overlay alloy hard-facing is also applied to the head section bearing journal which fits inside the cone. Here, heat is required over a larger surface area and the oxy-acetylene method of hard-facing is used.

Pressure vessel electrodes, supplied by Quasi-Arc Limited, are used, amongst others, to weld the three sections of each rock bit together.

Laboratory Furniture

During the planning of the new research laboratory of Hoover Limited, Perivale, Middlesex, a new concept in laboratory furniture was evolved in which movable table-structure benches and mobile under-bench units serve the dual purpose of providing under-bench storage and 40% additional bench area when required. The following notes on the equipment are from Hoover Research Report RP23, by J. Merritt and A. J. Fry.

The concept of the furniture evolved initially from the consideration of bench height, and 3 ft 4 in. was finally considered the best compromise, average elbow height being about 3 ft 6 in. This height (3 ft 4 in.) is about 2 in. lower than a bank counter, and about the same height as the jaws of a vice on a standard 2 ft 9 in. workshop bench. The length of the bench is largely a matter decided by the laboratory size, but not entirely. Two bench lengths of 8 ft 6 in. and 2 ft 6 in. were chosen. with a common depth (from back to front) of 3 ft. There is probably an advantage in standardizing 2 ft 10 in. rather than 3 ft. to allow easy table entry through 3 ft doorways.

Allowing 6 in. for the combined thickness of the bench rails and top, the under-bench units are 2 ft 10 in. high. Castor wheels on the under-bench units, bringing them about 3 in. from floor level (incidentally providing a toe-space), leave the internal height roughly 2 ft 6 in. which is adequate for most laboratory storage purposes. The depth of the storage space could be nearly 3 ft from back to front, but such a distance is impracticable since the back of such a cupboard would be very nearly out of reach. Hence, the under-bench units were restricted to a depth of 2 ft. Two lengths of under-bench unit seemed suitable, one 3 ft and the other 2 ft. Both these sizes are fitted either with drawers or as cupboards to suit the particular needs of this laboratory. Some large under-bench units are fitted as two-door cupboards, others with 20 small drawers for small components, and others each with four long and two half-length drawers. Small under-bench units are fitted as single-door cupboards or with five equal drawers. Cupboard shelves are adjustable to various heights and the castor wheels are fitted with foot operated brakes to stabilize the units whilst in use as benches. Rollers running on Formica strips ensure that heavily loaded drawers will run freely.

In order to give positive location to the under-bench unit, a stop rail is fitted under the bench top. By making this an 8 in. plank on edge, a substantial strengthening of the bench top is obtained as well. The bench tops themselves are all 1¼ in. solid teak, tongued and grooved and finished with raw linseed oil. The under-bench units are similarly topped with 1¼ in. teak since they serve the same purpose.

Laboratory stools were designed with foam rubber seats 11 in. below bench level. Since the seat is rather high above floor level (2 ft 5 in.), a rubber covered foot rail was provided.

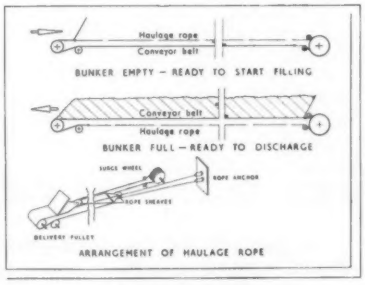
Beech wood and beech faced plywood was chosen for the structural material, being a strong light wood with a pleasing appearance. It is finished with high grade cellulose.

A purely timber constructed table with an 8 ft 6 in. span and no centre support is bound to warp, and it was found necessary to fit an angle-iron member along the front edge.

Bunker Conveyor

A means of providing temporary storage capacity in underground conveyor systems, preventing loss of output on power-loaded faces when delays occur in the haulage or winding cycle, has been devised by Mr. J. C. Mawson, area mechanization engineer in No. 1 Area of the National Coal Board's East Midlands Division. It is a bunker consisting essentially of a 42-in. wide special heavy duty conveyor belt which travels backwards and forwards in a structure with deep side-plates designed to contain a load of one ton per yard run of the belting.

The capacity of the bunker is 100 tons, and its overall height and width are such that it can be accommodated in a normal conveyor roadway with a tub track alongside. It can be situated at a transfer point in the conveyor system where the roadway floor is fairly level. In the event of a stoppage affecting the trunk conveyors, coal can be diverted into the bunker and stored there until normal working conditions are resumed. The contents of the bunker can then be discharged on to the trunk conveyor.



Method of operation

The method of operation is shown in the accompanying drawing. Each end of the belt is secured to a steel plate which carries a rope sheave; a flexible wire rope passes round this sheave from an anchor at the tail end, is lapped three times round a surge wheel (also at the tail end), and then passed round the sheave at the other end of the belt. The remaining end of the rope is again anchored at the tail end. Springs are incorporated in the rope anchors to maintain tension in the rope and belt. The surge wheel is driven by a motor and reduction gear box.

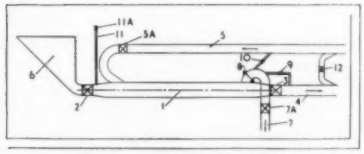
In place of the surge wheel drive, an alternative system, consisting of a travelling crosshead guided to move along the rope line, can be installed. This crosshead incorporates a clip device which automatically engages or disengages with the rope according to the direction of its travel; motion is applied to the crosshead by a pair of hydraulic rams. Two similar units are employed, to provide motion in either direction, and suitable hydraulic control gear is incorporated.

The bunker is filled by feeding coal via a chute on the belt at the delivery end. The belt is run in reverse, and the speed regulated so that the coal fills the hopper. When emptying, the belt is run forward and the coal is discharged on to a stage loader which in turn delivers on to the trunk conveyor.

Feeding Coal into Hydraulic Transport Systems

One problem involved in the development of systems of hydraulic transport of coal is the injection of the coal into a high pressure hydraulic main. This has been studied at the National Coal Board's Central Engineering Establishment, Bretby, where the horizontal lock hopper feeder illustrated has been developed; it is a modification, for convenience of installation underground, of a vertical feeder developed earlier at Bretby.

The feed of coal into the transfer chamber (1) is through a special hopper which is divided into two compartments, one containing a coal and water mix, and the other a column of relatively clear water. Delivery to the transfer chamber is so arranged that after coal ceases to flow from the coal compartment, clear water from the second compartment flushes the inlet valve (2) free of coarse coal before the valve is closed.



Horizontal lock hopper feeder

The transfer chamber (1) is of circular section and is long in comparison with its diameter. The inlet valve (2), as already stated, is linked with the feed hopper (6) and an outlet valve (3) is linked to the transport main (4). An extractor pipe (7), connected to an extractor pump, is

connected to the transfer chamber by a valve (7A) and filter (8). The purpose of this pipe is to enable water to be extracted from the chamber while it is being charged with coal.

The return main (5) is connected to the chamber near the inlet end through the valve (5A). It is also connected to the extractor pipe through valve (10) to enable the filter (8) to be flushed. Another pipe connects the transport main with the outlet end of the chamber through valve (9); this is to equalize pressure on both sides of the outlet valve (3) as coal is to be fed into the transport main. An atmosphere valve (11A) reduces pressure in the chamber at the end of the charging cycle.

The sequence of operations is that at the commencement of the cycle, the transfer chamber is full of water, the feed hopper contains coal and water, and all valves except the atmosphere valve (11A) are closed.

Valves (2) and (7A) are then opened enabling the extractor pump coupled to pipe (7) to induce a fairly high rate of flow in both the transfer chamber and the feed hopper, and the charge of coal flows into the transfer chamber. The filter (8) prevents the passage of any large solids to the extractor pipe.

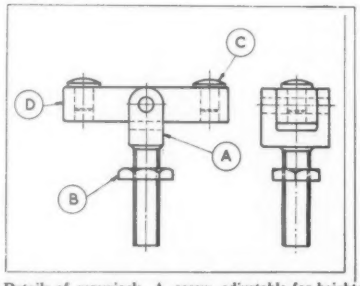
After the transfer chamber has been charged and the valve (2) flushed, the valves (2), (7A) and (11A) are closed, and valve (9) opened, bringing the pressure in the chamber up to that of the transport main. Valves (3), (5A) and (10) are then opened. The water flows from the return main into the chamber at the inlet end, flushing the coal out into the transport main. The opening of valve (10) enables "back-flushing" to take place on the filter (8).

When the chamber is emptied of coal, the cycle is completed by closing valves (3), (5A), (9) and (10) and opening valve (11A).

Adjustable Rocking Jack

Jacks, whether screwed or spring loaded, are useful in jig construction. The rocker type does not seem to be so well known, but when a dual support is necessary it will often eliminate two jacks and give much better degree support to the work-piece.

The drawing illustrates a screw jack with a rocker in the head, the height being adjustable by the screw A. The rocker arm B has sufficient swing in the forked end of A to accommodate the surfaces of rough castings or forgings. A locknut completes the assembly.



Details of screwjack. A, screw, adjustable for height; B, locknut; C, pads press against component; D, rocker arm

The locknut and the domed pins should be case-hardened.,

Welding Stainless Lining in Mild Steel Tanks

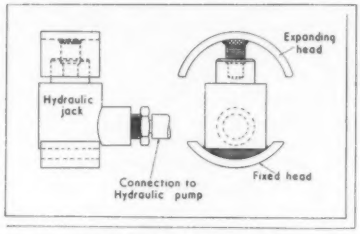
Of twelve large diameter tanks constructed by the Birmingham and Blackburn Construction Company Limited for the Plastics Division of Imperial Chemical Industries Limited and specially designed to contain corrosive liquid, the first two tanks were made of mild steel with a lining of rubber, but contrary to expectation the lining proved insufficient to arrest corrosion of the steelwork. The main barrels of the remaining tanks were therefore made of 18/8 stainless steel, welded with Quasi-Arc Chromoid No. 2 electrodes, the mild-steel reinforcements on the outside being welded on with Armoid No. 2 electrodes.

The mild steel roof was lined with Prodorglas, a corrosion-resistant synthetic material produced by Prodorite Limited, of Wednesbury, Staffs.

To avoid the expense and loss of production which would have been caused by replacing the two mild steel tanks with stainless steel tanks it was decided to line them with 18/8 stainless steel. The procedure was to weld stainless steel butt straps horizontally round the inside of the tanks, using Armoid No. 2 electrodes. The straps were spaced at intervals of three feet. Mild steel packing pieces were then inserted between the butt straps and stainless steel plates were then welded into position between the butt straps by the Argonarc process.

Tube Expanding Head

An hydraulically operated expanding head for use in repairing the outer pipe of Dowty props which have been damaged by hammer blows has been designed by Mr. William Dewhurst, charge hand at No. 2 Area Central Workshops of the N.C.B., North Western Division.



Expanding head for prop repair

The sketch shows the arrangement of the head; it is coupled to a hand-operated hydraulic pump with a capacity of 2½ tons. When a prop is to be repaired, the expanding head is placed inside the damaged outer tube, and heat is applied to the exterior of the tube by an oxy-acetylene torch. The hydraulic pump is then operated, and the head expands, forcing the dents out of the tube.

Argonarc Welding on Car Bodies

In view of the necessity for stability at high speeds, the chassis of the Austin Healey sports car is a fabricated steel structure of considerable depth, and additional strength is provided by the body side panels which are also of steel. The remainder of the shell, comprising the front and rear ends and the top decking, are of 16 s.w.g. aluminium-manganese alloy, B.S. 1470 N.S.3. The combination of materials affords considerable strength and results in a favourable overall strength-weight ratio. In the fabrication of the body shell by Jensen Motors Limited of West Bromwich, the Argonarc process is being employed for the welding of all panel joints.

In the complete car, the alloy structure consists of two large dimension one-piece sections, covering the whole of the upper surfaces before and behind the cockpit,

Preparing panel for welding

respectively. In order to simplify both assembly and tooling, each of the main panels is built up from a number of smaller sections which are welded together. This assembly method results in a reduction of both the size and complexity of formed parts, the majority of which are given their basic shape in a rubber-platen press.

The method of forming re-entrants, flanges and small cut-outs is hand panel-beating carried out in special jigs. Accuracy and perfection of finish on assembly is essential, and accurate jigging and a high welding standard are required to render the panel joints invisible. The Argonarc process affords protection from oxidation, enables welding to be carried out with speed, and only minimum distortion results from the cooling effect of the shroud of argon gas.

The jigs which clamp the panels firmly in alignment have been designed to maintain correct spacing between joint faces and also to control the underbead. The jig used for the nose assembly is provided with clamps which are specially shaped to form accurate welding guides. They automatically position the panels so that a weld gap of about $\frac{1}{16}$ in. is provided. For the bonnet top assembly, the upper half of the clamp is slotted along the centre line to give access of about $\frac{1}{4}$ in. on each side of the joint line. To provide easy access with the welding torch, the sides of the slot so formed are chamfered.

The degree of penetration is controlled by a semicircular groove on the lower fixed half of each clamp which provides a neat underbead which is $\frac{1}{16}$ in. wide and $\frac{1}{8}$ in. deep. All proud metal on the outer visible surface is ground away to provide a smooth finish, and the underbead forms a reinforcement to the joint, therefore. Post-weld treatment is not required.

Before the completed nose section is mated to the bonnet top panels, the upper rear edges are trimmed to the required angle by guillotines which provide the clean and accurate face necessary for welding. The nose section is then welded to the upper panels in another jig and the fabrication of the large front panel is then completed.

Each pair of torches is supplied with current from a Quasi-Arc ACP 2/300 transformer set which is capable of supplying 300 amp to each torch simultaneously. To provide immediate re-ignition of the arc at the zero point in each half cycle and to ensure automatic initial ignition without contact between the electrode and the work-piece, high-frequency units are inserted in each circuit. Also included in the circuit is a BOC d.c. suppressor unit. Mk. III water-cooled torches are used and the flow of argon and water is controlled by an economiser unit. Open-circuit voltage is 100 V, each torch taking 127 amp. The average welding speed is approximately 10 in. per min. Argon is fed at the rate of 12 to 16 cu ft per hr, and consumption of this gas is little more than 2 cu ft per body.

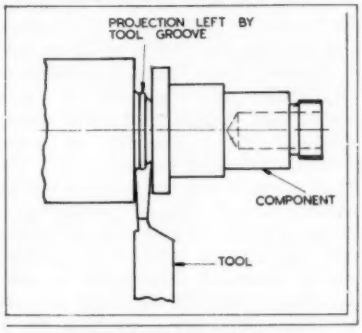
Parting-off Large Diameter Material

Parting-off large diameter components with a comparatively narrow tool often causes the latter to deviate from a true path—"run" as we say in the workshops—and this condition is frequently aggravated if any attempt to speed up the severing process is made. Many operators have experienced the fracturing of a parting tool blade through this condition without realising the real cause, and they have considered the only correction is an increase in blade thickness as a means of overcoming the problem.

A simple and effective remedy is depicted in the sketch—a narrow semicircular groove ground in the face of the blade to a depth of approximately $\frac{1}{16}$ in.

The severing of tubular components is another example where a tool of this type is useful because the groove has a steadying effect and overcomes the tendency for the tool to pull into the bore and so create a jagged hole on the workpiece.

Grinding tools in this manner on a turret lathe, centre lathe or automatic, improves their cutting qualities, and at the same time increases their normal life. A semi-circular groove is apparently preferable to one having a vee shape even if only because the former is easier to produce on a grinding



Parting-off tool with grooved blade

wheel, and if formed in a tool about $\frac{1}{4}$ in. wide such an alteration will allow the parting of pieces in the region of 3 or 4 in. dia without difficulty; the usual proviso being made of course, of keeping the tool always in a sharp condition.

For circular parting tools a similar groove ground round the periphery of the tool is easily made during manufacture with the result that no further grinding is necessary when the tool is re-sharpened. However, as most of the machines on which circular tools are used seldom cut off large diameter bar material, the addition of the groove is a refinement which has apparently little value, but if used on turret lathes such a tool is perhaps likely to give longer service than the usual shank type.

Electro-polishing

Electro-polishing is widely used as a metallurgical laboratory tool for the polishing of specimens prior to microscopic examination. It is, however, equally adaptable to commercial finishing as a process showing specific advantages in cases where a high finish is difficult to obtain by mechanical methods. Electro-polishing involves both macro- and micro-finishing, bath control being important to achieve the degree of finish required.

ELECTROLYTIC polishing, or electro-polishing, is now widely used on a commercial basis, particularly for the finishing of the more 'difficult' metals, such as aluminium and stainless steels, where manual polishing is tedious and not always entirely satisfactory. Electrolytic polishing is, of course, also a standard 'tool' of the metallurgist in the preparation of specimens for microscopic examination.

Broadly speaking, electrolytic polishing offers a superior result to mechanical polishing in many applications, but this is by no means universally true. Outside of laboratory controlled conditions, in fact, mechanical finishing remains quite adequate for a majority of commercial polishing requirements. Its main scope in the commercial world appears largely that of producing a superior finish on materials or forms not amenable to mechanical polishing, or materials susceptible to cold working, with the overlap as an attractive alternative method on a competitive cost basis still relatively limited, although this position may well change in the future.

Relatively little specific data, in fact, is yet universally agreed on the exact mechanics and electrochemistry of electrolytic polishing. The basis of the process is that the subject is made the anode in an electrolytic cell so that metal is lost to the solution in a preferential mechanical manner, i.e., the surface irregularities dissolved away.

Both electro-chemical and direct chemical action may be present in the cell, depending on the electrolyte and the nature of the bath operation. The effects may be that of normal etching, a finer form of dissolution classified as polishing, or a chemical change at the actual surface to produce 'passivation'.

In a controlled bath designed for electrolytic polishing the possible working conditions involve three separate phases—an etching phase during the initial part of the voltage/current relationship, followed by a polishing phase and, finally, gassing. Control is largely bound up with the formation of a viscous layer of solution enveloping the anode which determines the form of the voltage-current density curve, and the active operating point on the curve.

The actual 'mechanics' of electrolytic polishing is now generally agreed as combining two distinct effects—a smoothing action which is effective on macroscopic irregularities, and a polishing or brightening action effective on microscopic irregularities. In more general terms, the macroscopic irregularities are the normal 'peaks' and 'valleys' associated with a nominal surface finish, and the microscopic irregularities are further defects on the surfaces of the actual peaks and valleys. Thus removing macroscopic irregularities produces a smooth surface, but the final brightening is dependent on removing also the remaining surface blemishes. In mechanical polishing the conditions are quite different since the abrasive action involved attacks both forms of irregularities and, for fine polishing, is essentially micropolishing.

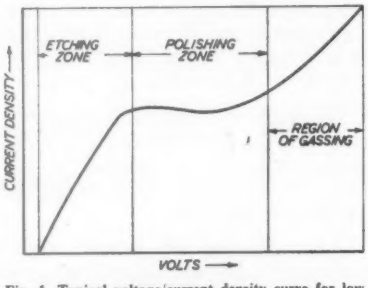


Fig. 1. Typical voltage/current density curve for low resistance electrolyte

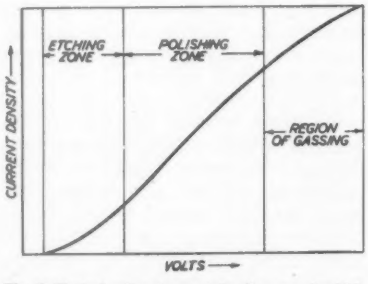


Fig. 2. Typical voltage/current density curve for high resistance electrolyte

The relationship between the aforementioned viscous layer and the type of electropolishing achieved is that the formation of a relatively thick viscous layer is consistent with macropolishing, and that of a thin viscous layer with micropolishing. With a thick film, for instance, there will be a difference in concentration gradient at a 'peak' and a 'valley', with resulting preferential dissolution of the 'peak'. In the case of a thin film, this follows the surface of the subject which is thus uniformly attacked by the electrolyte, hence producing a 'levelling' action associated with the brightening or polishing of the surface. The film theory also explains the difference between electrolytic polishing and etching. In the latter case the electrolyte has free access to the anode (subject) surface.

Two types of electrolyte are used for electrolytic polishing, classified as low resistance solutions and high resistance solutions on the basis of their electrical resistance. A low resistance solution requires a low voltage to establish polishing conditions and the bath operation is controlled by the applied voltage. A high resistance solution requires a high operating voltage and is controlled by means of current density. Characteristic curves for these two different types of electrolytes are shown in Figs. 1 and 2.

Low resistance electrolytes are usually based on phosphoric acid and other acids, e.g. typically

sulphuric acid and chromic acid, with or without the addition of organic reagents. The electrolyte may be balanced specifically to suit a particular metal (e.g. a 60–20 phosphoric-sulphuric acid bath for steel), although some are flexible enough to be used on a variety of metals.

High resistance electrolytes are normally based on perchloric acid solutions with acetic acid or acetic anhydride, alcohol and ether. These are also used for polishing steel as well as aluminium and aluminium alloys, magnesium, nickel, tin and zinc. A potential hazard is that such solutions may be explosive although suitable commercial electrolytes are available which overcome this defect.

Low resistance electrolytes are consistent with short-time polishing since the effective current density is high. A high current density, however, is not necessarily desirable due to the heating effects produced—the heat generated being proportional to the square of the current density. The viscous layer is a relatively poor conductor of heat and so the heat generated in the anodic envelope will be largely absorbed by the metal and if the rise in temperature is sufficient the film will be disrupted leading to direct attack or etching.

A further effect of temperature rise in the solution is a decrease in viscosity and consequent lowering of electrical resistance, resulting in an increase in current density again to aggravate the postion. Mechanical agitation by stirring or circulation of the electrolyte can be effective in eliminating local overheating, but again is a matter for careful investigation and control since excessive agitation may disrupt the anodic layer and modify the current density in the opposite manner.

With a high resistance electrolyte there is obviously less risk of overheating, but with the lower current density polishing time is prolonged. An excessive polishing time is not desirable as the quality of the finish may tend to deteriorate and actually accentuate surface defects.

Polishing time, of course, will also be influenced by the initial state of the surface to be treated. A finely finished surface will require less time to smooth and polish in the bath and under certain circumstances it may be advantageous to carry out a certain amount of pre-finishing to minimize electrolytic polishing time. In general, however, the solution chosen would be balanced against current density and time requirements.

Additional factors which may affect the results achieved include the control of current density effected by the relative positioning of cathode(s) and anode and the age of the solution. It is obviously important that the current density should be uniform over the whole surface of the anode, which can only be achieved by correct spacing of the cathode and subject. The effect of bath ageing is that the metallic content of the electrolyte will tend to increase with age since more metal is dissolved from the anode than is deposited out on the cathode. This effect, fortunately, may actually be beneficial, within the limits of the normal life of the bath, due to the increase in conductivity of the solution.

Summarizing, although the mechanics of the process are complex and not yet fully explained, electrolytic polishing may be extended to a wide range of metals, there being numerous proprietary solutions available for the treatment of specific metals. Some general information of types of electrolytes employed are summarized in the table.

BASIC APPLICATION OF TYPICAL ELECTROLYTE TYPES

Electrolyte Type	Metals	Remarks
Phosphoric Acid	Steel Copper & Brass Cobalt, Magnesium, Tin, Zinc	Low resistance electrolyte
Perchloric Acid	Aluminium Aluminium Alloys Cadmium Lead Magnesium Magnesium Alloys Nickel Nickel Alloys Steel Tin Tin Alloys Zinc	High resistance electrolyte
Nitric Acid—Methyl Alcohol	Alumium Copper Copper Alloys Nickel Nickel Alloys Steel Stainless Steel Zinc	Adequate cooling of bath essential
Ethyl Alcohol and Dissolved Chloride	Alumium Alumium Alloys Chromium Cobalt Nickel Stainless Steel Tin Tin Alloys Zinc	Suitable only for small anode areas (e.g. for Metallurgical Polishing)

Gas from Low-grade Coal

A Scottish Lurgi plant using coal from an opencast site

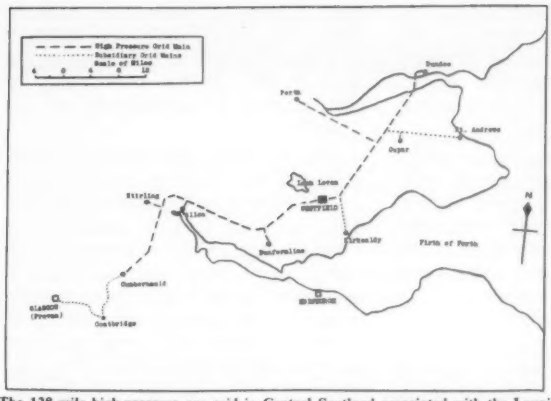
LOW-GRADE opencast coal will be fed by conveyor-belt directly from a National Coal Board site into the new £6,500,000 gas plant to be built for the Scottish Gas Board at Westfield, near Loch Leven. For the first time in Britain, the Lurgi pressure gasification process will be used because it enables gas to be made from low grade coal, containing up to 25% ash and 16% moisture—unsuitable for normal carbonizing plant.

Tests on the Westfield coal have been carried out in a pilot plant in Germany to confirm the operating results which will be obtained. When completed, the plant will have a capacity of 30 million cubic feet of gas per day. An interim stage, valued at £4 million, will be built for an output of 15 million cubic feet per day.

The gas will leave the plant at high pressure—over 250 psi—which will enable it to be distributed over long distances (for instance, Glasgow) in a comparatively small gas main without additional boosting.

The main contract for the new works has been awarded to Humphreys and Glasgow Limited who, in association with the Power Gas Corporation, have reached an agreement with Lurgi Company of Germany to build this section of the plant.

The coal will be completely gasified in the Lurgi generators at a pressure of about 25 atmospheres in a continuous stream of oxygen and superheated steam. Heat in the crude gas from the generators will be used to produce steam in waste heat boilers. Tar, oils and ammonia in the effluent will be recovered, the ammonia being concentrated in a plant to produce a 20% solution for sale. Benzole, a valuable by-product, will also be recovered from the crude gas.



The 128-mile high-pressure gas grid in Central Scotland associated with the Lurgi gas-making plant at Westfield in Fife, showing some of the principal centres served

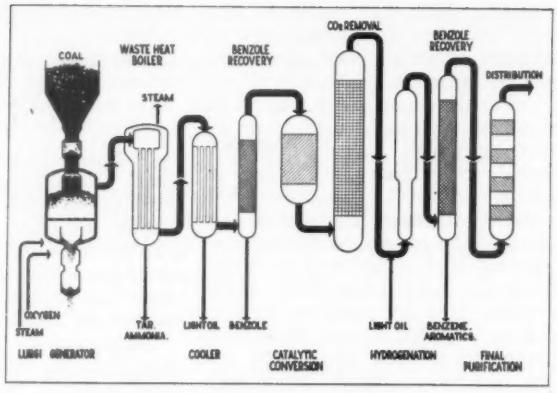


Diagram of Lurgi pressure gasification plant

The proportion of hydrogen in the gas is increased by a catalytic conversion plant. Carbon dioxide is next "washed" out in a Benfield plant. The gas is then enriched by the hydrogenation of oil. This process has been developed by Dr. F. J. Dent, Director of the Gas Council's West Midlands Research Station, where Humphreys and Glasgow have already built a one million cubic feet per day hydrogenation pilot plant.

Finally it will pass through a further benzole recovery plant, recovering high purity benzene, before passing through pressure oxide purifiers, in which the final traces of hydrogen sulphide not removed in the Benfield plant will be taken out to meet the Gas Referees' requirements.

Coal fed into the Westfield works, by a belt conveyor from the adjacent opencast mining bunkers, will be sized up to 3 in. It will be fed to a screening plant, where coal below $1\frac{1}{4}$ in. will be separated from the larger material, which in turn will be crushed to below $1\frac{1}{4}$ in. for use. The coal will pass on another conveyor to a second screening house, fitted with special resonant screens, where it will be separated into two streams: that to be used in the gas generators $\frac{1}{8}$ in. to $1\frac{1}{4}$ in., and that to be used in the boiler plant for steam raising $\frac{1}{8}$ in. or less. Ash collected from the boiler plant and gas generators will be returned to the opencast working.

The Lurgi generators will give a crude gas having a calorific value of about 300 B.Th.U. per cu ft. Ultimately the output of purified Lurgi gas will be about 22 million cubic feet per day. When enriched in the subsequent processes, this will give a total works output of 30 million cubic feet per day of town's gas.

Oxygen required for the gasification process will be obtained from two air separation plants, which also produce nitrogen. The nitrogen will be used for adjusting the combustion characteristics of the gas at the end of the process stream.

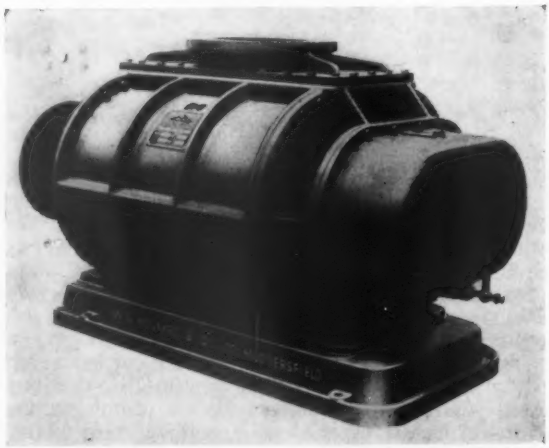
To increase the percentage of hydrogen in the Lurgi gas for the subsequent enrichment process, a shift reaction will be used to produce hydrogen and carbon dioxide from the carbon monoxide which is present in the gas. This reaction is carried out at high pressure and temperature in the presence of iron oxide catalyst.

Following the catalytic conversion of the carbon monoxide, the carbon dioxide produced—together with the carbon dioxide originally present in the crude gas and the bulk of the hydrogen sulphide—will be washed out in the Benfield plant. Humphreys and Glasgow are licensees for this process, the principle of which is the absorption of carbon dioxide and hydrogen sulphide in hot potassium carbonate solution. The steam required in the process will be supplied from the waste heat boilers. When it leaves the Benfield plant, the gas will have a calorific value of about 400 B.Th.U. per cu ft. Enrichment by the hydrogenation process will raise the calorific value to about 700 B.Th.U. per cu ft, with a specific gravity of about 0·44.

Before distribution, the gas will be diluted with nitrogen to the normal calorific value of town's gas, 450 B.Th.U. per cu ft, and a specific gravity of 0·5.

In the interim stage, when the plant will have a capacity of 15 million cubic feet per day, the crude Lurgi gas will pass straight to a Benfield washing plant, and the gas with a calorific value of 400 B.Th.U. per cu ft will be enriched with butane before distribution.

The boiler plant to meet the process and turbo-alternator requirements at Westfield will have an output of 150,000 lb per hr, producing steam at 450 psi pressure at a temperature of 680° F. The turbo-alternator will have an output of 7150 kW and this will meet all the needs of the plant.



RB HOLMES-CONNERSVILLE AIR BLOWER.–The latest type a 12 in. machine fitted with roller bearings incorporates a redesigned H-type casing which has now been adopted for the whole range. Introducing a small clearance between the revolving impellers and the surrounding casing dispenses with the need for internal lubrication and results in oil-free air delivery. The 12 in. range offers air capacities of 3100 cfm at 1 psi up to 1010 cfm at 10 psi according to size. The makers are W. C. Holmes & Company Limited, Turnbridge, Huddersfield

Adhesive Bonding of Titanium Alloy

A stainless steel honeycomb faced with titanium alloy sheet raises manufacturing problems arising out of differential expansion. Results are given of a production-scale investigation

MANUFACTURING research engineers at Boeing Airplane Company in the United States have recently come to the conclusion that it will be possible to adapt metal-bonding equipment and procedures now used for aluminium to bonding one of the thermal-resistant materials, 6A1–4V titanium, with a minimum of facility changes and additions. Their experience in producing a variety of bonded assemblies for both B–52 and KC–135 aircraft meant that they had at hand advanced techniques for use with aluminium.

On the basis of these techniques, a series of experiments were carried out to determine the problems that would be encountered in bonding titanium alloy on a production scale. Seven assemblies were bonded with titanium faces and stainless steel honeycomb cores. Since no previous data existed, the investigation accumulated valuable information. Most important, it proved that all of the problems basic to bonding titanium skins and either stainless steel or titanium honeycomb cores could be solved.

These were discovered when the engineers bonded the titanium and steel-honeycomb panels using the same procedures as for bonding aluminium. On the basis of the difficulties found, they established the following facts: (1) existing tooling needed modification; (2) temperatures between both sides of the bonded assemblies needed close control; (3) costs had to be cut wherever possible if the alloy was to be bonded on a practical production basis.

The use of conventional tooling materials such as aluminium and mild steel for bonding titanium assemblies introduces a problem in its own right. This is to be expected because of differential values in coefficient of expansion. Bonding operations for aluminium skins raise no such problems since the "locators" which hold the parts during the bonding process can be mounted on an aluminium base. The question was whether titanium could also be used for a tool base for bonding parts made of titanium.

The immediate objections were: titanium is expensive, difficult to machine, and unavailable commercially in the sizes commonly required.

New techniques, then, had to be developed for using conventional tooling materials. For short parts, an aluminium base with several possible materials—grey iron, structural steel, 17-7 PH, SAE 1008 steel, SAE 1020 steel, or 6A1–4V titanium—to carry the locators could be used. The part dimensions and tolerances determined the materials selected. In any case, a compensator attached to the base was free to expand at the same rate as the part. The tool could, of course, be re-used.

Another method for avoiding use of titanium parts as tools was the substitution of a mild steel base with zinc compensator. Again the length of the part determined the length of the compensator. A formula could be applied: the length of the compensator would be equal to the difference in coefficient of expansion of the base and of the part, divided by the difference in coefficient of expansion of the compensator and of the base; and the ratio multiplied by the length of the part. Thus it was possible to use a combination of materials whose expansion characteristics gave a net match between the titanium details and locators.

It was also necessary, however, to consider the rate of expansion with respect to temperature. Materials were selected which have coefficients of expansion that vary with temperature at nearly the same rate as titanium. The effect was to minimize strain set up as a bonded assembly returns to room temperature from bonding temperature. A general expression for the mismatch of compensators and parts is $X = P(ET^2 + FT + G)$ where X is the mismatch, P is the part length, and T the temperature. E, F, and G are determined from equations of the coefficient of expansion of the respective materials as functions of temperature. The equation is a parabola which intersects the T axis at upper bonding temperature and room temperature. X is a maximum at the mid-point (about 230° F). Using mild steel for the base, zinc for compensators, the maximum mismatch X was 0·003 in. when the part dimension at room temperature was 120 in.

Temperature control was found to be essential in order to maintain specified cure cycles and to control warpage. Titanium skin, stainless steel honeycomb sandwich panels have a low thermal conductivity. Cure cycles of upper and lower skins are not readily maintained to specification when heating from a single platen, the temperature varying with core thickness. The temperature also varies slightly with skin thickness. To study bonding cycle control, then, as well as causes of warpage, several stainless steel panels with various skin and doubler combinations were fabricated and bonded. They varied in size from 9 by 11 in. to 23 by 25 in. They were all bonded with high temperature adhesive in an air-cavity pressure facility mounted in a 200 ton, heated, double-platen press. Attempts were made to control the bonding cycle temperatures and to define, in a bonding cycle the completed polymerization point of the adhesive. All panels warped when there was a temperature differential between the upper skin and the lower skin during bonding. What was needed was a more accurate definition of the polymerization point on the resin cure cycle and a tighter control over skin temperatures around this point.

A flat sandwich panel approximately $\frac{5}{8}$ in. × 36 in. × 72 in. consisting of 0·072 in. 6A1–4V titanium skins and stainless steel 17–7 PH core ($\frac{1}{4}$ in. cell size) was fabricated to study the problems further. The panel was bonded in an air cavity pressure facility at 60–64 psi with Shell 422 J adhesive. Single platen heating was used with the air cavity pressure facility installed in a

200-ton heated double-platen press. Severe warpage (approximately 0·15 in. in 6 ft) was apparent. It was thought that the warpage had been caused by a large temperature differential between the upper and lower skins at the time of bonding since the temperature recording chart indicated a 25° to 40° difference in the skins during the cure cycle. Single-platen tests then indicated that heat losses were actually responsible for the warpage. It was reasonable to assume that a suitable insulation material might control and raise the temperature of the unheated side of the sandwiches during bonding by reducing radiation and conduction losses. Tests of five insulation materials showed how bonding cycles varied with insulation. The best insulation material proved to be laminate of three-ply of foil with two-ply glass wool. It reduced heat loss sufficiently so that specified bonding temperatures could be attained. A graph of the cure cycle on $\frac{5}{8}$ in. thick panels showed how insulation improved temperature control. Further tests established other requirements for temperature control; for example, heating and the upper platen has a decided effect on a cure cycle with $\frac{5}{8}$ in. core in bond. The temperature difference between the skins was reduced to 10°.

Generally, then, temperature control was found essential to maintain a specified cure cycle but it is also essential to control warpage.

The warpage is due primarily to temperature differences between the two skins to be bonded at the time the adhesive becomes rigid. The problem, then, was to determine when and where in the bonding cycle the adhesive becomes rigid. Once this point was found, the temperatures could be controlled to the degree necessary to control warpage.

It was determined that the warp could be defined by the relation $R = X/CT$ where:

R = radius of curvature
X = thickness of honeycomb
T = temperature difference between skins
C = coefficient of expansion of skins.

If T is small, R is large and warp is minimized.

In the heat treatment of 6A1–4V titanium skins there is a warp formed during the quenching operation. Warpage can be removed during the ageing process by confining the sheet in the flat position during the 1000° F age cycle. The skins, however, do not always come out as flat as, for example, aluminium skins from the rolling mill. Fortunately, the bonding process requires pressure which is available to flatten these skins further during the cure process. It was found that a titanium skin of 6A1–4V in the quenched and aged condition with "oil cans" (wrinkles) in excess of 0·1 in. high can be flattened enough to have undulations under 0·009 in. high (valley to crest) when only 10 psi fluid pressure is applied.

In bonding with stainless steel core, pressures as high as 50 psi can be used, resulting in undulations under 0·005 in. Bonded structure is considered good when bond thicknesses are controlled to less than 0·000 to + 0·005 in. from the optimum. Exploiting the pressures required during the cure process thus materially reduced the rejection of skins for bonding, and incidentally reduced costs.

The bonding pressures necessary for this operation were obtained from a pressure differential caused by evacuating a space sealed off by a rubber diaphragm that covered the entire assembly. Using this technique along with proper insulation and double platen heating, panels without significant warpage could be produced on a production scale.

Any method that will decrease the cost of bonding 6A1–4V titanium will contribute also to improving its capabilities for use on a production scale. One important area of investigation thus was in the salvage of bonded parts from rejected assemblies which might otherwise have been scrapped. While it is probable that parts can be salvaged for flyaway assemblies, tool qualification and research costs can be substantially reduced for fabrications where strength of assemblies is not required.

In the salvage process devised during the investigation into temperature control and tooling, the assembly was heated to 850° F and held for 45 min. It could then be taken apart. The cured adhesive residue was cleaned off the parts with nitric acid. Hydrogen contamination, thought beforehand to be large, amounted only to 48 parts per million. The salvaged parts were perfectly reusable.

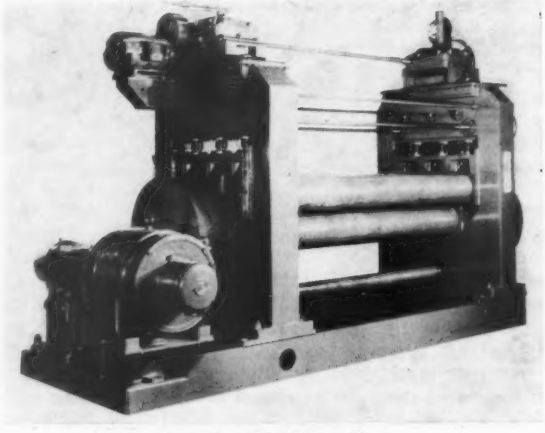
Five-roll Levelling Machine for $\frac{3}{4}$ in. M.S. Plate

A five-roll plate levelling machine for cold mild steel plates up to a maximum of 8 ft wide and up to $\frac{3}{4}$ in. thick at a levelling speed of 16 fpm has been designed by Bronx Engineering Company Limited, Lye, Worcs.

The levelling rolls consist of three top and two bottom rolls each being $12\frac{1}{2}$ in. dia and machined from 0·45% C steel forgings. The roll necks are finished ground running in seal-protected bearing assemblies.

Power from a 50 hp 960 rpm reversing motor controlled by a full-load reversing controller is transmitted through a special coupling to a worm reduction gear box, reduction gearing and through a train of gears to the bottom rolls. This latter gear box is also totally enclosed. All gears are machine cut from carbon and nickel gear steels.

The top rolls are adjustable by hand or by a $7\frac{1}{2}$ hp reversing motor at 960 rpm. The top ingoing and outgoing rolls are independently adjustable with individual handwheel adjustment.



Bronx five-roll levelling machine

High Pressure Pneumatics

Compressed air operated systems are now being worked at pressures of 6,000 psi for servo power, and 3,000 psi systems are suggested as a standard for aircraft use, comparable in performance with a 3,000 psi hydraulic system with a marked reduction in weight. Specific advantage of a pneumatic system is high speed of operation, due to the elasticity of the pressure medium

CONVENTIONAL industrial pneumatic systems operate at pressures of the order of 80–100 psi. A pressure of 50–80 psi is usual in most factory lines. Portable compressors used to provide power for pneumatic tools, etc., are designed for usual operating pressures of 80 to 100 psi, and single stage rotary compressors for pressures up to 60 psi.

These figures are, of course, very much below the maximum pressures which can readily be achieved by multi-stage compressors. High-pressure compressors are invariably of the reciprocating type, when a two-stage unit can achieve up to 1000 psi, a three-stage unit 3000 psi, a four-stage unit 5000 psi, up to an eight-stage unit delivering 7000 to 10,000 psi, in generalized figures.

To be competitive with hydraulics in specific engineering fields, obviously a high pressure pneumatic system is called for. An inherent limitation for general engineering application is that in the ordinary workshop such facilities for producing high pressures are not readily available, and to achieve similar duties with a low pressure pneumatic system demands a prohibitive size of cylinder. As a potential form of power, however, compressed air may have certain advantages over hydraulic systems.

One particular advantage is that pneumatic systems are less susceptible to extremes of working temperature than any system employing fluids as the power medium. Whereas the working limits of a hydraulic system are bounded by the viscosity-temperature characteristics of the fluid, air systems can operate up to temperatures in excess of 400° F, and also down to extremes of low temperature. The latter feature is particularly significant for a problem with low temperature hydraulic operation on both the limiting performance of the fluid and the loss of elastomeric properties of seals and packings at such temperatures. Pneumatic systems, having no adverse chemical effects on seals, permit the use of natural rubber seals which retain resilience and elasticity down to minus 80° F, whereas with oil systems only a castor-base fluid would be compatible with natural rubber seals and packings.

A pneumatic system also has the advantage of greater speed of operation. In all oil systems fluid velocity is normally limited to within the range of about 10 to 15 ft per sec in pressure lines, or occasionally up to 30 ft per sec for intermittent duty. The velocity of compressed air is very much higher, even in low pressure systems, due to the compressibility of the medium. At 80 psi lines pressure, for example, the air velocity is of the order of 600 ft per sec.

This, of course, also points to an inherent hazard with a high pressure pneumatic system—the potentially explosive nature of a system failure. It is well known, for example, that when pressure testing a container to destruction with water, unless any air in the system is completely removed the final failure will be of an explosive nature. Liquids are inherently non-compressible (although they are, in fact, quite measurably compressed by high pressures) and represent no explosive hazard on their own under pressure. In a hydraulic system this is not necessarily true, however, for a failure in the system will release the fluid in the form of a high velocity mist or spray, which can represent a fire hazard with conventional fluids of mineral-oil base. For this reason alone special non-flammable hydraulic fluids have been developed, specifically for aircraft hydraulic systems and industrial systems where such a fire hazard may be very real (e.g. for hydraulically-operated die-casting machines).

These, and other factors such as lighter weight and cleaner operation, make the high pressure pneumatic system a particularly attractive alternative to hydraulics or electrical operation for aircraft control systems—a field in which it is steadily achieving more favour. It is certainly not a new form of power for aircraft systems for pneumatics have been widely applied to aircraft during the past decade or more and a stand-by pneumatic system is more or less standard for emergency power in the event of failure of a hydraulic system. But more designers are being attracted to the idea of using pneumatics as a primary system and high pressure pneumatics in that field is now receiving something like the concentrated development and attention which virtually revolutionized the application of hydraulics during and immediately following the war years. The particular significance of this is that any major developments in the aeronautical engineering field, where operating requirements are particularly exacting, is generally of benefit to the whole of the engineering fields in introducing new and better techniques on an already well-established basis.

One of the earliest applications of pneumatics to aircraft systems was in the operation of wheel brakes, starting some twenty-five years ago with system pressure no greater than the average industrial systems but working up to about 450–500 psi as more and more demands were imposed on the system. Until comparatively recently, in fact, aircraft pneumatic systems of 1000 psi have proved adequate (except for the stand-by systems used for emergency power and normally stored in air bottles). Currently a 3000 psi storage system is generally accepted as being required to meet

TYPICAL PNEUMATIC SYSTEM PRESSURES

Supply: single stage rotary compressor for general use	60	psi
double-stage rotary compressor for general use	120	,,
General factory lines	80	,,
Pneumatic tools	80-100	,,
Spray painting	50-100	,,
Plastic moulding machines	500	,,
Heavy servo mechanisms	500-600	,,
Low pressure aircraft systems	450-600	,,
Medium pressure aircraft systems	1,000	,,
High pressure aircraft systems	3,000	,,
Torpedo drives	4,000	,,
Charging hydraulic accumulators (from bottles)	5,000	,,
Guided missile control systems	6,000	,,

modern needs and be directly competitive with 3000 psi hydraulic systems, with the storage capacity balanced to give an actual operating pressure at the actuators of the order of 1000–1400 psi under conditions of heaviest demand. The saving in weight achieved over a comparable hydraulic system is then of the order of 25 to 30%, for a typical aircraft installation. Just as there are higher pressure hydraulic systems, however, (5000 psi systems are being tried on an experimental basis) higher pneumatic system pressures have also been evolved, in keeping with the evolution of miniaturized, lightweight components for more compact or 'packaged' systems. In the guided missile field pneumatic systems operating up to 6000 psi are in use, charged in this instance on the ground.

A particularly interesting development has been the production of high pressure containers which are fragmentation proof, in both light alloy materials and resin-impregnated glass fibre. Common forms are cylindrical for the light alloy containers, formed in one piece without joints or seams, and spherical for the glass plastic units. Both forms have been proved by firing tests in which a fully charged container is pierced with 0·50 calibre bullets, when the damage is confined solely to the entry and exit holes of the bullet without splitting or tearing of the walls of the container. Thus the previously mentioned explosive hazard is entirely removed, with the system also immune to fire risks, both particularly attractive features from the military aircraft point of view. Both types of container, incidentally, have proved superior to spherical steel pressings brazed together.

An essential feature of a high pressure system is that the air should be clean and dry on the working side. This is accomplished by detail design of the compressors limiting the amount of oil contamination to a very low figure and finally removing oil and water in a suitable trap and dehydrator positioned before the storage container or containers. This means that only those seals in the actual compressor and regulator circuit are subject to oil contamination and need to be of oil-resistant elastomer. It is, of course, a characteristic of a pneumatic circuit that there is no return system to a reservoir, as with hydraulic systems which further simplifies the problem of 'clean' operation as well as resulting in an appreciable saving in line length and weight.

High pressure pneumatic rams and cylinders are characterized by small size, light weight and high operating speed. The last has obvious advantages and one, in particular, not so obvious disadvantage. This is that without some form of damping or braking the stroke may be concluded only by slamming hard against the stops. This was particularly noticed on retractable undercarriage systems, normally hydraulically operated, when actuated under emergency pneumatic power especially in cases where there was no appreciable air load on the unit to provide the necessary braking or damping action. It was originally overcome by by-passing air to the opposite side of the piston to provide an artificial load. Present practice is to provide for braking or artificial load by a form of dashpot or oleo damping. The higher the system pressure the faster the inherent speed of operation and the more important artificial damping may become in systems subject to variable or light external loading.

The all-pneumatic aircraft system would, logically, also employ a pneumatic stand-by system for emergency operation of the critical controls, following a failure of the main system. This would be fed from a separate container or storage bottle, charged initially with the main system or separately on the ground. Provision would also have to be made to exhaust or relieve any parts of the main system which may otherwise contain trapped high pressure air opposing movement under emergency system pressure.

Certainly the future for high pressure pneumatics would appear particularly bright in the aircraft field, and with the diminution in size of cylinders required to produce high working forces, to be also attractive in other industries where hydraulic systems may represent undesirable fire hazards. The die-casting industry is one, although largely satisfied with the introduction of suitable non-flammable fluids. The cleanliness of the system could appeal to users where contamination must be avoided at all costs—e.g., in tobacco processing plant —and for this reason may currently be using water-hydraulic systems. Other obvious fields of application include those where the service temperature is high, or extremely low, calling for special cooling or heating, respectively, of conventional hydraulic fluid systems to maintain a satisfactory fluid viscosity. Lightness and compactness of a high pressure pneumatic system may also attract users outside the aircraft industry.

The attachment greatly assists timber handling

Mobile Crane Attachment Carries Long Loads

To increase the versatility of the B.H.C. Iron Fairy, a hydraulic mobile crane which was first described in our November, 1956 issue, the makers the British Hoist and Crane Company Limited, Compton, Berks., have introduced a useful ancillary for handling lengthy materials. Known as the Long-Stuff Carrying Attachment, it consists of a steel platform fitted to one side of the Iron Fairy, opposite to the driver. Long loads picked up can be lifted and slewed round and lowered on to the platform and the jib returned to its original lowered position. To facilitate the operation the front portion of the platform attachment is made in a telescopic form.

Loads of 30 cwt and measuring 20 ft or more can easily be carried, the cross sections size being up to 2 ft wide by 3 ft deep. Anchor chains are included in the platform design for securing the load while travelling.

Electro-magnetic Coupling Offers Wear-free Constant Torque Control

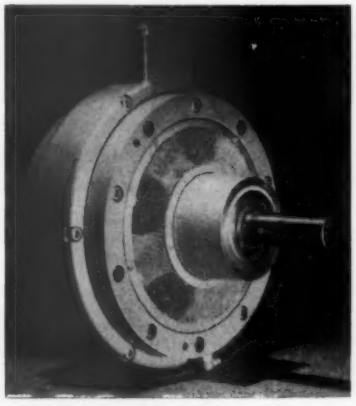
Freedom from mechanical engaging parts with their attendant wear, a constant torque performance independent of speed—these are the salient features of the new magnetic particle coupling introduced by S. Smith & Sons (England) Limited, Witney, Oxon., for industrial drives.

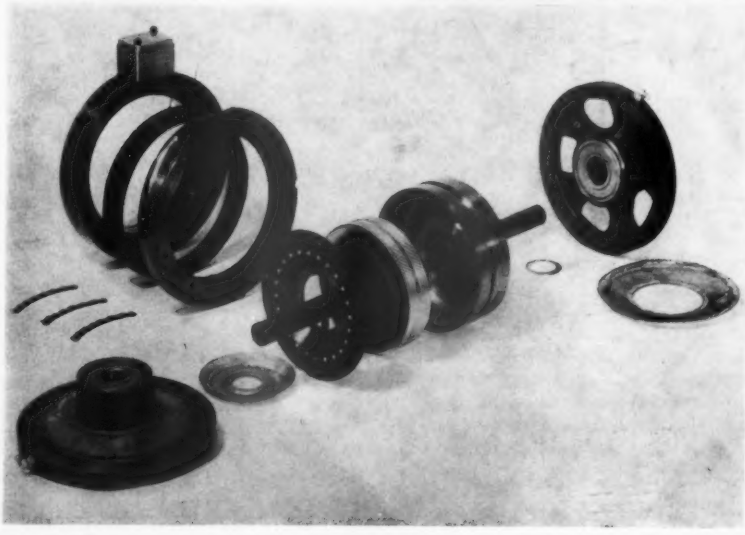
The basic elements of the coupling are few; it contains two rotors one within the other, the outer one being coupled to the input shaft and the inner one to the output shaft. The air gap separating the rotors contains a quantity of ferro-magnetic powder. Around the two rotors is a stationary field member containing an exciting coil, with an air gap between it and the input rotor. When current is applied to the coil, magnetic flux is created which crosses the air gap between the stationary member and the input rotor, and the powder gap between the input and output rotors. When the flux passes through the powder, the particles are attracted between the pole faces in such a way that torque, proportionate to the degree of excitation, is transmitted from the input to output rotors. Thus the powder which is dependent on the magnetic flux density in the air gap, behaves in a similar manner to the hydraulic fluid used in fluid flywheel transmission systems.

The main advantage claimed is the complete absence of snatching or juddering encountered with hydraulic devices during engagement. Under full excitation, the coupling becomes solid, and as no slip takes place no loss of efficiency arises from generation of heat.

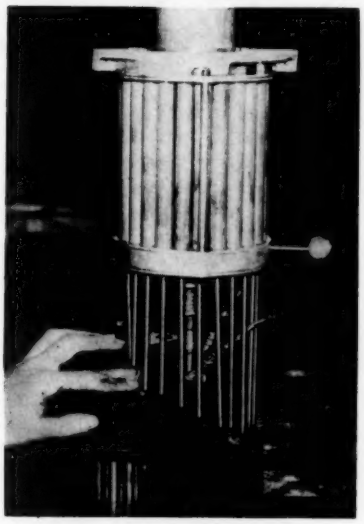
These couplings are available with torque capacity of ½, 1, 6, 12, 25, 50, 100 or 200 lb/ft; and operate from 24 V or 180 V d.c. as standard, though special voltages can be catered for. Power consumption varies according to the size of the coupling—for the 50 lb/ft coupling shown in the illustration it is 72 W.

By achieving accurate control of the torque by the exciting current the Smith coupling lends itself for use on any machinery maintaining constant tension or torque on the workpiece or product. This clearly covers a very wide range of applications.





Right, Smiths magnetic particle coupling for industrial drives type No. SFU 550/50. Below, the components of the coupling. On the left, in the background, is the stationary field member, with its winding. The shafts in the centre carry (right) the input member, and (left) the output member and the back plate for the input member. When assembled, the output member is fully enclosed, and the input member back plate has integral with it a labrynth plate to keep the magnetic powder in its working area.



The guard fitted to a radial drill spindle.

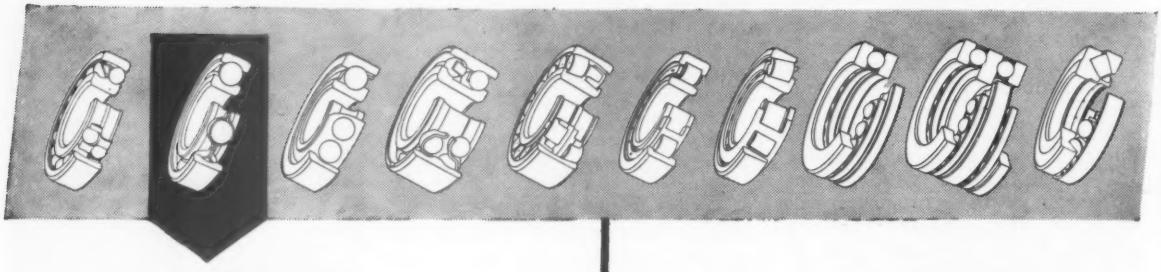
Spring-loaded Plungers Form a Drill Spindle Guard

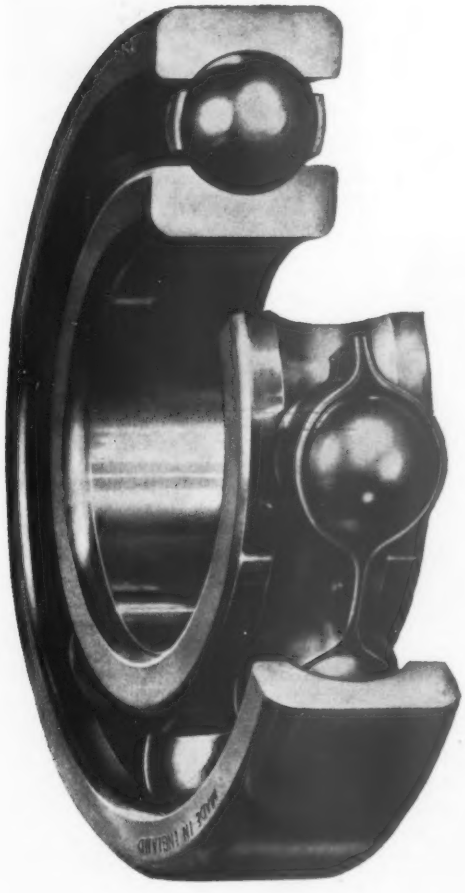
A safety guard for radial arm drills which employs a system of spring-loaded fingers to take up any shape of work on the machine table has been patented by Newton Chambers and Company Limited, of Thorncliffe, Sheffield. It fully covers the requirements of the Factories Acts and is claimed neither to hinder production nor interfere with the movements of the operative. Any length or size of drill may be used and drill changing is quick and simple. The guard is firmly clamped to the lower portion of the machine sleeve, and is supported by a bearing from the spindle. As the movement is taken up with the reciprocating sleeve, the appliance still remains effective whatever the extension of the sleeve or barrel.

Eclipse Tools at Brussels

A distinctive display of engineers' tools has been contributed by James Neill & Co. (Sheffield) Limited to the stand arranged by the Birmingham Engineering Centre at the Brussels Exhibition. Four panels show the Eclipse range of hack saws and blades, sheet saws, surface gauges and small tools, cobalt high speed steel tool bits and tool holders, and Eclipse permanent magnets and magnetic chucks. It is interesting to note that the Eclipse No. 20T hack saw frame and the No. 55 sheet saw are also featured on the stand of the Council of Industrial Design.

Only SKF *can offer such a wide selection of British made bearings*

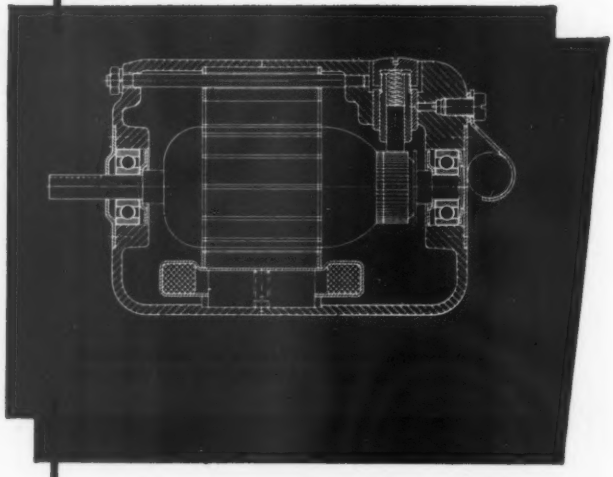




Illustrated here is the single row deep groove ball bearing, the most widely used of the ten variants of the four basic types of ball and roller bearing made by The Skefko Ball Bearing Co. Ltd.

The groove depth, ball size, and high degree of conformity between balls and tracks enables SKF single row deep groove ball bearings to deal with considerable thrust loads in addition to radial loads even at very high speeds.

A unique fund of technical information and experience lies behind the design of every SKF bearing—experience which is freely available to you whenever you have a bearing problem.



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Engineering Materials Handbook. Edited by Charles L. Mantell. New York, 1958; McGraw-Hill Book Company. London; McGraw-Hill Publishing Company Limited. £8-7-0 net (by post £8-9-3). Approx. 2000 pp. 6 × 9 in.

The product of the efforts of more than 150 contributors, this bulky volume arose out of a graduate course for practising engineers. In it the emphasis is on the fabricated forms of materials —their physical and mechanical properties, adaptation, advantages and limitations, competitive relationships, and the improvement of their stability. The range of working temperatures covered by the data presented ranges from that of liquid helium to carbon volatilization, and of pressures from the lowest vacuum to thousands of atmospheres.

The books has 43 sections. The first two deal with the properties of materials and fabricated forms and processes. Then follow sections on metals and metallic forms covering cast iron and steel; aluminium, copper and lead and their alloys; magnesium, nickel, tin and zinc alloys; beryllium, cobalt, columbium, manganese, molybdenum, tantalum, thorium, titanium, tungsten, vanadium and zirconium; platinum, palladium, gold, silver and other precious metals; arsenic, antimony, bismuth, cadmium, chromium, the alkaline earths, gallium, germanium, indium, lithium, the rare earths, rhenium, selenium, tellurium and thallium; liquid metals; laminated metals; magnetic materials and electrical alloys; electrical conductors and contacts; electroplated coatings and allied processes; wear-resistant surfaces, and powder metallurgy and cermets.

The next group of sections deals with stone and minerals; reinforced concrete; brick, structural clay products and refractories; porcelain, stoneware and vitreous coatings; glass and silica; following which there are sections on carbon and graphite; wood and related materials and paper; textiles, felts and cordage; hydrocarbon-base materials; rubber and elastomers; plastics; organic coatings, and insulation. The concluding sections are concerned with the deterioration of engineering structures; corrosion and protection against it; the materials of construction for the process industries; pipes, fittings and valves; gaskets, packings, adhesives and cements; wire, chains and sheet; materials problems of specific industries (communications, railways, petroleum, electron valve, jewellery), and the sources of information on engineering materials in the United States.

Casting in Steel. London, 1958; Sir Isaac Pitman & Sons Limited on behalf of The British Steelfounders Association. 18/- net (by post 18/9). 112 pp. 6 × 9 in.

During the past decade The British Steelfounders Association has published a series of bulletins addressed primarily to those who design and buy steel castings in the belief, rightly founded we think, that steel castings could be applied to advantage over a wider field if engineers and designers were better informed as to their characteristics and functional attributes. The bulletins have been widely distributed and readily accepted and their success has led to their appearance now collected into book form. The volume deals with all the aspects which concern the user, describing some of the processes and showing how customary practices and treatments influence the finished casting, and concludes with a useful summary of British Standards on steel castings.

Hydraulic Handbook. London, 1958; Trade and Technical Press Limited. 90/- post free. 764 pp. 7 × 9¾ in.

Hydraulic machinery nowadays presents a picture of development most of which is comparatively recent and far beyond the hydraulic machinery which developed about a century ago and remained with but little change until the advent of power control in recent years for machinery, aircraft and the like, and for actuation in presses and machine tools. Now there is hydraulic equipment of refined design to suit a multitude of purposes as the book under notice shows very clearly. The book provides a comprehensive information service, whether on principles, types of equipment, applications, technical data, or on where the equipment can be bought. Over 100 pages are devoted to principles alone, and the other topics are equally well covered. The technical data include diagrams of hydraulic circuits, various tables, charts and nomograms, a dictionary of terms, a list of symbols, and a useful collection of formulae.

Fluid Pressure Mechanisms. By H. G. Conway. London, 1958; Sir Isaac Pitman & Sons Limited. 32/6 net (by post 33/4. 235 pp. 5½ × 8½ in.

The modern hydraulic system is characterized by a number of highly developed details, notably moving seals, a number of special designs of valve, a number of equally special pump designs, a range of receiving units of varying degree of complexity according to their purpose, a further group of valves designed for selection, i.e. initiating operation and control, still further valves for pump pressure control, others for system pressure control, more yet for controlling flow to say nothing of the miscellaneous other valves and components which contribute to the refinement and precision of the modern hydraulic system. In addition, the indispensable piping has comparably developed fittings to suit many applications and conditions. All these details are carefully described in this book, and equally well illustrated. In the text there is very full discussion of pressure systems, arranged logically from the elementary power systems to the remote control, variable speed, sequence, servo and electric control systems. In this second edition the excellent method of treatment adopted in the first edition has been continued and the book enlarged with some sixty new diagrams and new material in a good many places.

Galvanizing Manual.—A manual of good practice issued by the Hot Dip Galvanizers Association, 34 Berkeley Square, London W1, price 25/- post free, sets out in simple terms all the essential factors for efficient processing and improving the quality of the coatings. The galvanizing process is outlined and the merits of the wet and dry methods of galvanizing described. The preparation processes such as degreasing, paint removal, pickling and fluxing are considered in detail, and special attention is paid to the careful preparation of castings for galvanizing. A comprehensive section deals with the actual dipping of the products and besides examining the factors

'Eclipse' hacksaw blades and other tools are made by James Neill & Co. (Sheffield) Ltd. and are obtainable from all tool distributors

UH23

which affect the quality, thickness and uniformity of the coating, contains recommendations on bath composition. Bath temperatures, rate and time of immersion and aspects of withdrawal are also considered. The important factors in testing and inspection are described together with ways of measuring the coating thickness. British Standards 417, 729 and 1565 for galvanizing are reviewed and the method of carrying out the Preece Test is described. Recommendations on transport and correct storage conditions to prevent white rust are given. The manual concludes with a description of a number of finishing treatments and emphasises the value of calcium plumbate paints for direct application to newly galvanized steel.

Costing for General Galvanizing.—Accurate costing is of particular importance in the general galvanizing industry which has to deal with a wide variety of quite different articles, each giving rise to special problems. A manual of costing practice which has been issued by the Hot Dip Galvanizers Association, 34 Berkeley Square, London W1, price 35/- for the two volumes, post free, has been prepared by Mr. W. E. Harrison (Past President of the Institute of Cost and Works Accountants) working with a small committee drawn from within the industry. In two volumes, one containing the text, the other some twenty-eight forms which can be used in operating the costing systems, it is a complete guide to the galvanizer wishing to initiate cost finding procedures. The two methods of costing used in galvanizing, i.e. the bath hour rate and the job or unit costing system are described and the elements that make up the cost of galvanizing are specified, the relationship of cost accounting to accounting is explained and the importance of integrating these functions stressed. Separate chapters deal with all aspects of direct material, direct labour, indirect factory and administration, selling and distribution costs. Various methods of allocating the cost of zinc and residuals are also outlined. The use of cost information in estimating, in incentive application, standard costing and cost control is explained, and in using standards for control purposes the importance of establishing the reasons for variances is emphasized and, more important, the need for management to correct inefficiencies revealed by these variances. A way in which costs can be compared between galvanizing companies is described.

Tin Research.—The report of last year's work of the Tin Research Institute indicates that all departments were actively engaged in pursuing new ideas and developing fresh applications of tin. A notable achievement was the publication of a method of producing electroplated deposits of tin in a fully bright form. The Institute's invention of a method of bonding aluminium-tin bearing alloys to steel has reached the commercial stage of development and thousands of cars have already been fitted with the new type of bearings. Tin as an impurity in cast iron has always been frowned upon but recent work sponsored by the Institute at the Battelle Memorial Institute, U.S.A., shows that small amounts of tin may bring about desirable structural changes without detriment to the mechanical properties. Corrosion studies have been concerned with the nature and structure of oxide films on tin and tinplate; both natural and artificially produced films are being investigated. The adhesion of lacquers to tinplate is also being studied.

Diesel Centenary.—The centenary of the birth of Rudolf Diesel in Paris on March 18, 1858, is commemorated by The Power Petroleum Company Limited, 76–86 Strand, London WC2, in an illustrated booklet which traces the development of the diesel engine from its early stages to the considerable variety of applications which it finds today.

Instructive also are the notes on fuel development, which has evolved with the compression ignition engine and which has done much towards the refinement of the reliable and efficient engines of today. The book has a series of interesting photographs of engines of different periods.

New Standards

Voltages for a.c. transmission and distribution systems (B.S. 77: 1958). Price 3/-.

This further revision of B.S. 77 has been published mainly because of the changes in the organization of the electricity supply industry in the United Kingdom since the last edition appeared; the scope of the standard has been extended to cover industrial systems as well as public supply systems. The only recognized standard voltage for 3-phase 4-wire distribution systems is 415/240 V. The number of standard voltages above 1000 V has been reduced, but 330 kV and 380 kV have been added to the list. Preferred voltages for new installations are clearly indicated.

Phenolic resin-bonded cotton fabric sheets for electrical purposes (B.S. 2966:1958). Price 6/-.

B.S. 2966 specifies requirements for a range of phenolic resin-bonded laminated cotton fabric sheets of natural colour made from layers of cotton fabric bonded with thermosetting resin of phenolic type. The materials are intended for electrical applications and the standard is concerned with the performance of the material under working conditions. Three types of material are classified and, depending on the type, the thickness of the sheet ranges from $\frac{1}{16}$ to 4 in.

Code of Practice for Mechanical Ventilation and Air Conditioning in Buildings. C.P. 352:1958. Price 20/-.

Prepared on behalf of B.S.I. by a committee of experts from the Institution of Mechanical Engineers and the Institution of Heating and Ventilating Engineers, this 112-page publication forms a valuable guide to modern practice in designing, planning, installing, testing and maintenance of mechanical ventilating and air conditioning plant.

The head-code deals with general matters such as time schedules, district surveyors' or local authorities' fees, design, inspection and testing and maintenance.

The eight sub-codes treat in detail the following subjects: fans, motors and starting gear; air heaters; air distribution system; air cleaning devices; thermal insulation; soundproofing and anti-vibration devices; temperature and humidity controls and cooling and dehumidification.

The text is amplified by ten fully annotated diagrams and charts.

British Standards Institution, 2 Park Street London, W1.

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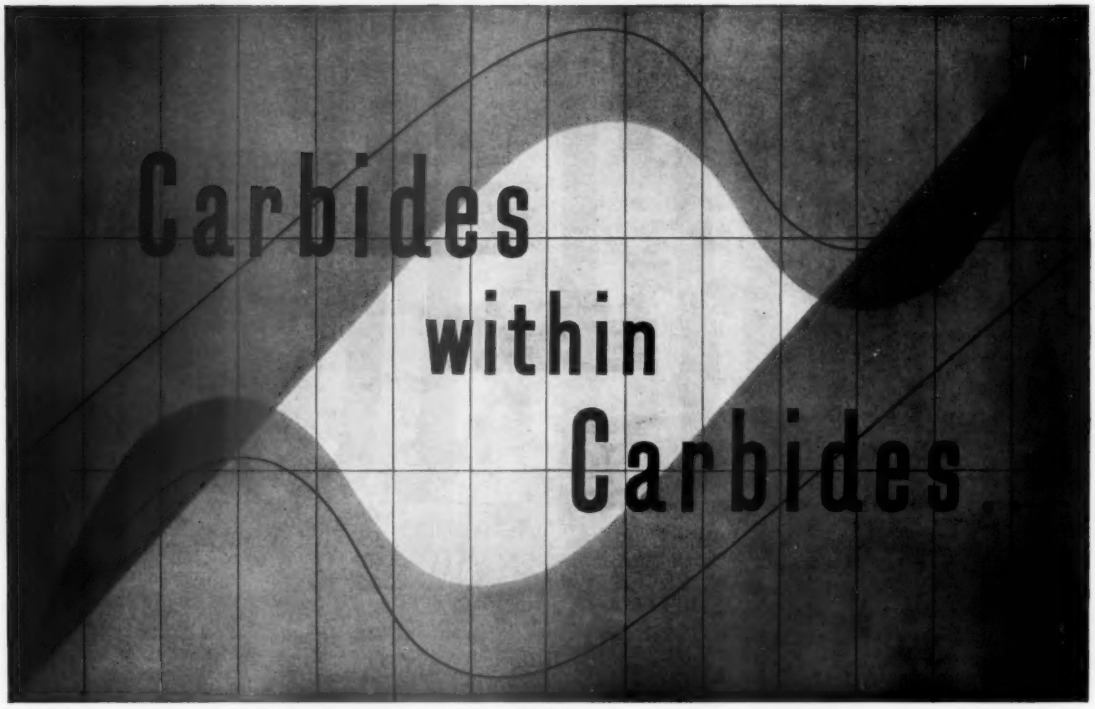

Edgar Allen & Co. Ltd. have installed a completely new works for the production of a wide range of tungsten and other carbides and tools. Specialized equipment enables quick delivery to be made.

For many purposes in modern industry carbide tools are made and are usually of sintered tungsten carbide type. Allenite carbides differ from these, being specially processed, graded, and subjected to strict technical and chemical control. The special refractory metal carbides in the carbide give greater abrasion resistance and hardness without loss of ductility, as well as less liability to 'cratering'. Planing a box steel casting of 22 tons with faces of over 20 ft., where 1½"—2" material had to be removed, an Allenite Plowrake tool on a 45 ft. planer took a ⅝" depth of cut with a .050" feed at 85 ft. per min! Normally with previous tools only 25 ft. per min. was attained. Here, the Allenite tool gave perfect satisfaction. Allenite carbides are, therefore, of tungsten carbide *plus!* Write for further information, using the request form.

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BUSINESS & PROFESSIONAL

Personal

Mr. Monty Prichard, M.C., deputy managing director of F. Perkins Limited, has been appointed joint managing director of the Peterborough diesel engine company with Mr. Frank Perkins, who now becomes chairman and joint managing director.

Mr. C. H. Flurscheim, B.A., M.I.E.E., Mem.A.I.E.E., chief electrical engineer of Metropolitan-Vickers Electrical Company Limited, has been appointed a director of the company from April 1958. **Mr. O. T. Evans, Assoc.M.C.T., A.M.I.Mech.E., A.M.I.E.E.,** is appointed chief engineer, electrical general engineering department. The electrical general engineering department comprises the mining and rolling mill divisions. **Mr. L. H. J. Phillips, B.Sc.,** former sales manager, electronics department has been appointed assistant commercial manager. **Mr. A. G. Barton, Assoc.R.T.C. (Salford), A.M.I.E.E.,** succeeds Mr. Phillips as sales manager, electronics department.

Captain J. A. Creed, V.R.D. and bar, R.N.V.R. (Retd.) has been appointed deputy managing director of Robert Boby Limited, Bury St. Edmunds.

Mr. A. T. Webster, A.M.I.Mech.E., who joined Leyland Motors Limited as a trade apprentice 20 years ago, has now been appointed manager of the company's Australian branch. He accompanied Mr. D. G. Stokes, Leyland director and general sales manager, on a business tour in Australia before taking up his new appointment.

Mr. W. E. A. Williams has been appointed Sifbronze technical representative with Suffolk Iron Foundry (1920) Limited (Stowmarket), for London and South-East England. Mr. Williams will operate from 100 Preston Lane, Tadworth, Surrey. Telephone No.: Burgh Heath 6536.

CAUSEWAY REINFORCEMENT LIMITED (a member of the Amber group of companies) of 66 Victoria Street, S.W.1, announce the appointment of **Mr. Desmond Bowditch** to the board. Mr. Bowditch joined the company as general manager in 1957, from the Henry C. Stephens Limited group of companies where he was also general manager.

Mr. W. P. Scott, manager, condensing department, Worthington-Simpson Limited retired in March last, after holding this position for 22 years. The condensing department will now be administered from Newark by **Mr. T. Trowsdale,** condensing sales manager, and **Mr. T. Bennett,** condensing contracts manager.

AUSTIN CROMPTON PARKINSON ELECTRIC VEHICLES LIMITED, announce the following rearrangement of area managers' territories: **Mr. W. Wilson,** Scotland, Cumberland, Northumberland, Westmorland, Durham. **Mr. S. G. Beer,** Yorkshire, Lancashire, Cheshire, North Wales, Northern Ireland. **Mr. J. B. Blacknell,** Warwickshire, Worcestershire, Staffordshire, Hereford, Shropshire. **Mr. C. F. Williams,** Gloucester and South West England. **Mr. A. Steadman,** Derbyshire, Nottingham, Leicestershire, Northampton, Huntingdon, Rutland, Cambridge, East Anglia. **Mr. J. R. C. Williams,** Oxford, Buckingham, Berkshire, Surrey, Hampshire, Kent, the Isle of Wight, Bedford and part of Hertfordshire. **Mr. F. Spalton,** London area. **Mr. Peter Rochs** has been appointed the company's public relations officer.

Mr. T. G. Gibson, Crompton Parkinson (Stud Welding) Limited, has returned to Glasgow to take up his appointment as stud welding sales engineer for Scotland, N. Ireland and Eire.

AFTER fifty years' connection with Weir and Drysdale products, **Mr. Leslie C. Brown,** Birmingham office manager and technical representative of G. & J. Weir Limited, Cathcart, Glasgow, retired in March last. He is succeeded by **Mr. Gavin Murison,** who has been transferred from Weir's London Office. Mr. Murison served his apprenticeship at the company's works at Cathcart.

Mr. F. Moore has been appointed deputy chief engineer of Steel, Peech & Tozer, a branch of The United Steel Companies Limited. Mr. Moore joined United Steel as an engineering apprentice at the Appleby-Frodingham branch in 1922.

Mr. J. M. L. Howell, sales manager (earthmoving) of Distington Engineering Company Limited, a branch of The United Steel Companies, Limited, has been additionally appointed sales manager (mining). Mr. Howell has been at Distington since 1955.

Mr. John P. Coleman, M.I.E.E., has resigned from the board of Data Recording Instrument Company Limited, in which he no longer has any financial interest, in order to give his full attention to the activities of the Gresham-Transformer Group, of which he is chairman.

CROFTS ENGINEERS (HOLDINGS) LIMITED announce the appointment of **Mr. Granville Horsley** to the board of the Company and also his appointment as joint managing director of the operating company, Crofts (Engineers) Limited.

Mr. W. J. Weston, Assoc.I.E.E., M.Amer. I.E.E., M.A.M.E.M.E., has been appointed Birmingham area manager of Lancashire Dynamo Group Sales Limited with effect from April, 1958.

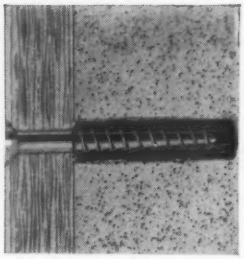
VICKERS LIMITED announces the following changes in Group organisation: **Mr. J. H. Robbie, C.A.,** is appointed a director of Vickers-Armstrongs Limited; **Mr. E. P. Tomlinson, A.C.A.,** is appointed commercial director of Vickers-Armstrongs (Engineers) Limited in place of Mr. Robbie; **Mr. A. Lawrence Cooper** is appointed secretary of Vickers Limited in succession to Mr. Tomlinson and **Mr. J. McLean, A.C.A.,** is appointed deputy secretary. Mr. Tomlinson is succeeded as secretary of Vickers-Armstrongs Limited by Mr. McLean and as secretary of Vickers-Armstrongs (Aircraft) Limited, Vickers-Armstrongs (Engineers) Limited, Vickers-Armstrongs (Shipbuilders) Limited and Vickers-Armstrongs (Tractors) Limited by **Mr. T. P. Houghton, A.C.A.** **Mr. T. C. Raymond** is appointed a special director of Vickers-Armstrongs Limited.

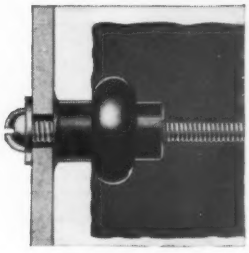
Mr. Joseph Cowley, assistant sales manager of Edgar Allen & Company Limited has retired at the age of 70. Mr. Cowley joined the company in 1902. After experience in the foundry and tool steel departments and later as representative in the Lancashire area, he was appointed assistant sales manager in 1932. **Mr. L. Lamplugh** is appointed sales engineer in the engineering department. He was formerly a technical manager with Head Wrightson & Company Limited.

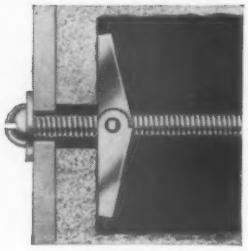
Mr. C. A. Flint has been appointed secretary of Sparklets Limited and **Mr. J. B. Shott** has been appointed chief accountant.

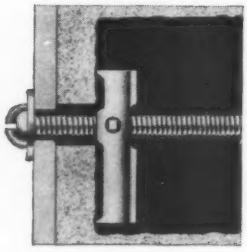
THE following appointments have been made by Expandite Limited, manufacturers of jointing materials, sealing and waterproofing compounds, Chase Road, London, N.W.10: **Mr. T. Pooley,** sales director, has been appointed deputy managing director; **Mr. E. L. Townsend** has been appointed to the board as director in charge of overseas develop-

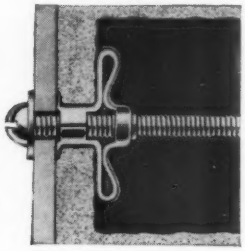
SOLID OR CAVITY MATERIALS





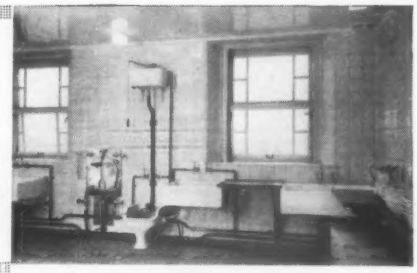




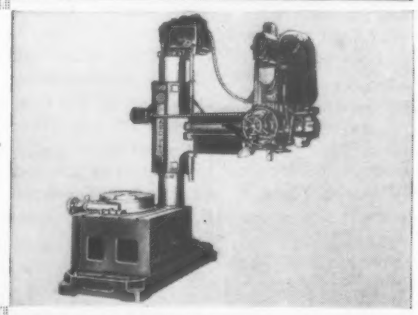


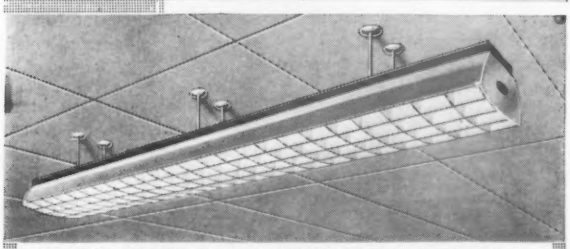
Rawlplug fixing devices save you time and money

SCREW FIXINGS
Use the famous RAWLPLUG for neat, firm fixings in brick, stone, etc. All sizes for up to $\frac{3}{4}$" diameter Coach Screws. Rawlplugs are waterproofed and unaffected by climatic conditions.



BOLT FIXINGS
For bolting down machines, light or heavy, use RAWLBOLTS, a dry fixing that grips by expansion. No cold chiselling, no waiting for cement to harden. Sizes up to 1" bolt diameter.





CAVITY FIXINGS *The amazing RAWLNUT, screwed up from the front, forms its own rivet head behind the material—airtight, watertight, vibration-proof, squeak-proof! For all thin or hollow materials.*

B591

Fixing methods that served well enough in bygone days fall far short of modern standards of efficiency, when an average machine can be safely bolted down *and in operation* within an hour or so of arrival!

Rawlplug Fixing Devices always save time and therefore money, for it is a simple *fact* that on *every* screw and bolt fixing job, in solid *or* cavity materials, you'll make strong, absolutely safe fixings in *far less time than by any other method.*

You can easily prove this for yourself. The first step is to write for full details of the 21 different types of Rawlplug Fixing Devices. Write us now —and if after studying our literature, you have any difficulties about a particular problem, our Technical Service specialists will be delighted to advise you without obligation.

RAWLPLUG

FIXING DEVICES

THE RAWLPLUG COMPANY LTD
CROMWELL ROAD, LONDON, S.W.7

ments; **Mr. J. M. Robb,** manager of the Overseas Division, has been appointed general manager Expandite (Australia) (Pty.) Limited and will shortly be taking up the post in Australia. **Mr. J. H. Humphries** has been appointed area manager Scotland, and **Mr. A. W. Moignard** assistant area manager for South East England.

WILLIAM JESSOP & SONS LIMITED and their associated company J. J. Saville & Company Limited, announce that **Mr. D. Milne, C.A.** has succeeded the late Mr. F. Briggs, F.C.I.S., as secretary. **Mr. J. V. Gregory** has been appointed assistant secretary.

THE BRITISH THOMSON-HOUSTON COMPANY announce the following changes in managership of various district offices: **Mr. F. C. Barford, T.D., M.I.E.E.,** has relinquished his position as manager, Birmingham District, following his recent appointment as manager, small industrial machines department, Blackheath, Birmingham. He is succeeded by **Mr. K. J. Clarke, A.M.I.E.E.,** from Sheffield district where he has been manager since October 1957. **Mr. W. J. Wilson, A.M.I.E.E.,** manager, Leeds district succeeds Mr. K. J. Clarke at Sheffield, and **Mr. J. N. Griffiths** is appointed manager, Leeds district.

THE SKEFKO BALL BEARING COMPANY LIMITED announce that **Mr. L. E. Willson,** hitherto manager of the company's Southampton Office has been appointed an assistant sales manager at the company's head office in Luton, Bedfordshire. He will be succeeded at Southampton by **Mr. G. T. Boden** from the company's London office.

MOBIL OIL COMPANY announce that **Mr. A. Peck** is now manager of the distribution department and **Mr. N. P. Huntley** has succeeded him as manager of consumer fuels department. These moves are necessitated by the appointment of **Mr. F. R. Squires,** formerly manager of distribution department, to the new post of manager of retail divisions.

THE FAIREY AVIATION COMPANY LIMITED announce that **Dr. G. S. Hislop,** formerly chief designer (Helicopters) is appointed chief engineer (Aircraft), and **Mr. L. R. E. Appleton, O.B.E.** (formerly head of Guided Weapon Design and Development) is appointed chief engineer (Heston). They will both be directly responsible to the Technical Director, Mr. Robert L. Lickley.

THE retirement is announced of **Mr. W. H. Grinsted, O.B.E., F.C.G.I., M.I.E.E.,** director of engineering of Siemens Edison Swan Limited. Mr. Grinsted joined Siemens Brothers in March, 1911. In 1945 he was appointed chief engineer of Siemens reconstituted telecommunications department and in 1946 received the award of the M.B.E. (Civil Division) in recognition of his outstanding and devoted work during the war years. In 1952 his services received further recognition by the award of the O.B.E. At the Siemens centenary dinner held in London in March last, Mr. Grinsted was the recipient of a special presentation made to him, on behalf of the directors of the company by Lord Chandos, chairman of Siemens Edison Swan Limited, and of Associated Electrical Industries Limited.

Colonel R. T. Hartmann has resigned his appointment as executive director of British Straddle Carrier Company Limited of the Fisons Group of Companies, which appointment he has held since September 1953, in order to devote more of his attention to the business of Materials Handling Equipment (Great Britain), Limited, 40a Dover Street, London, W.1, of which he is managing director.

Mr. S. M. Maude A.M.I.M.E., A.M.I.P.E., has been appointed works manager of Anderton Springs Limited, and Dee Kay (Engineering) Company Limited, of Bingley. Both firms are closely associated for the manufacture of circlips and springs by modern mass production techniques.

Obituary

WE regret to record the death at the age of 78, of **Mr. John Hampton Pawley** a director of George Cohen Sons & Company Limited, whom he joined 51 years ago. Up to last December Mr. Pawley was in day-to-day control of the firm's dismantling activities, involving every year the negotiation, and general supervision, of hundreds of major contracts in Britain and Overseas.

Addresses

BRITISH INSULATED CALLENDER'S CABLES LIMITED have moved their Dundee branch office to 2 South Ward Road, Dundee, Telephone 5926/7. The company has also changed the address of their Hull branch office, which is now 49 Mytongate, Hull, Telephone numbers 16470 and 16367.

E. H. JONES (MACHINE TOOLS) LIMITED have now moved their London area office to their new premises at Edgware. Their London area address is now 48 High Street, Edgware, Telephone: Edgware 4488/9.

PETBOW LIMITED, Sandwich, Kent, manufacturers of welding equipment have formed an associate company in Canada for the purpose of expanding the sales of their products and organising their own servicing facilities. The title of the new company is Petbow (Canada) Limited and their offices and works are at 26 Taber Road, Rexdale, Ontario, Telephone No. Cherry 4-5529, Cable Address Petbowld, Toronto.

LANCASHIRE DYNAMO GROUP SALES LIMITED have opened a new sales and service office in Ipswich The territory covered from this office will include Suffolk, Norfolk, Cambridgeshire, Huntingdonshire and the northern half of Essex. The address is 12 Princes Street, Ipswich (Ipswich 56141/2). Mr. B. L. Perkins, B.Sc., A.M.I.E.E., has been appointed manager of the Eastern Area Office with a fully qualified engineering staff.

THE Manchester offices of Dictaphone Company Limited have removed from Deansgate to Woolwich House, 59-61 Mosley Street. Telephone: Manchester Central 9740 and 9746.

THE Australian subsidiary of Geo. Salter & Company Limited, West Bromwich, spring and spring balance makers, has changed its name from Whitelaw Springs Pty., Limited, to Geo. Salter (Springs) Pty., Limited. The company's address, Grosvenor Street, Abbotsford, Melbourne, N.9, and Telephone number JB.2729, are unchanged.

JACKSON & BRADWELL LIMITED manufacturers of dynamic and static balancing machines have removed from their premises at 32 Paradise Street, Birmingham, 1 to Grove House, Sutton New Road, Birmingham, 23. The new telephone number is Erdington 7411/2.

FONADEK (BRANSON) LIMITED of Harborne, Birmingham, manufacturers of electronic telephone equipment, have moved their London offices from Wigmore Street to larger premises at 442 Chiswick High Road, W.4. Telephone: CHIswick 8561.

RANSOME & MARLES BEARING COMPANY Limited have moved their South West Area office from Bath Parade to larger premises at Transom House, Bristol. The new telephone numbers are 20437–8.

International Industrial Organization

IN order to further the development of industrial projects in the Middle East in conjunction with Arab and other local interests the Federation of British Industries recently announced the formation of an international organization called MIDEC S.A. Its registered office is in Luxembourg at Rue Aldringer No. 14 and

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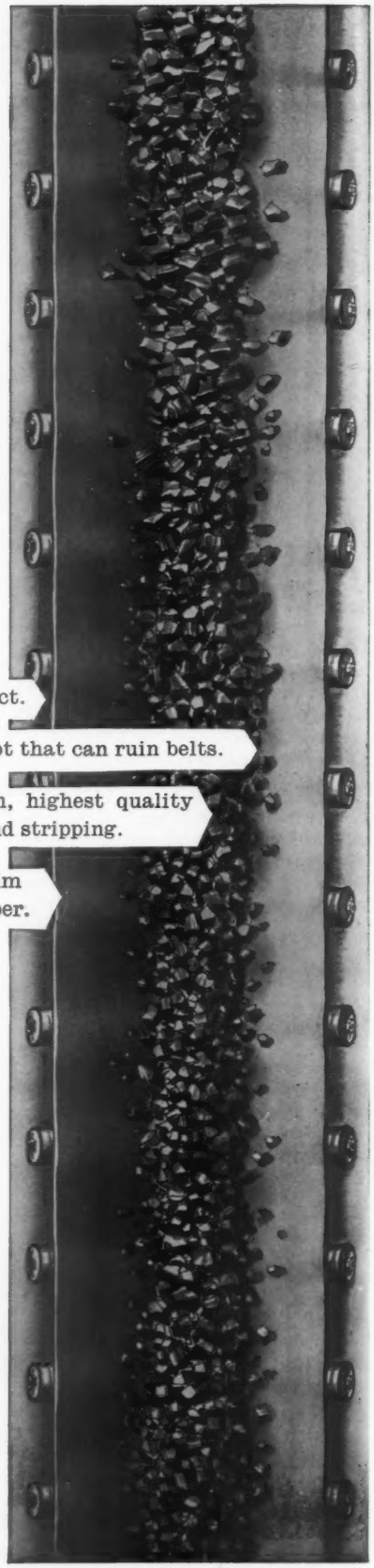
Then get Goodyear, the world's most economical, most widely used belts

Whatever materials you convey there is a Goodyear Conveyor Belt that is made to do the job—at the lowest cost per ton.
These are the features essential for dependable, long belt life service—the features you get when you buy Goodyear.

1. **Proper troughing** that ensures correct idler contact.
2. **Mildew-inhibited** construction prevents mildew rot that can ruin belts.
3. **Longest cover life** that comes from use of tough, highest quality covers that ensure maximum resistance to abrasion and stripping.
4. **High flex-life**—greater flex-life because of skim coating between plies with highest quality friction rubber.



Remember that Goodyear technicians are always available to ensure that you get the right belt for the job and will advise on installation and maintenance.

Write now for further information to the Goodyear Tyre & Rubber Company (Great Britain) Limited, Industrial Rubber Products Department, Wolverhampton.

GOODYEAR

INDUSTRIAL RUBBER PRODUCTS

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it also has branches in the Hague and Beirut. The present participating countries in MIDEC S.A. are Belgium, Canada, Denmark, France, Western Germany, Holland, Italy, Norway, U.K., Sweden, Switzerland and the U.S.A. The total initial share capital of MIDEC S.A. is Swiss Francs 1m. The shares allotted in MIDEC to the U.K. have been taken up by (Banking) British Bank of the Middle East, The Chartered Bank, The Ottoman Bank. (Contracting) Balfour, Beatty & Company Limited, Taylor Woodrow (Overseas) Limited. (Manufacturing) Associated Electrical Industries Limited, British-American Tobacco Company Limited, The Dunlop Rubber Company Limited, Guest Keen Iron & Steel Company Limited, Imperial Chemical Industries Limited, Platt Bros. & Company (Holdings) Limited, The Power-Gas Corporation Limited, Schweppes Limited, Standard Telephones & Cables Limited.

H.M. Factory Inspectorate

DIVISIONS and districts of H.M. Factory Inspectorate have been revised. The new names of the fourteen divisions and the addresses of the relevant H.M. Superintending Inspectors are given below: **Northern,** Prudhoe House, Prudhoe Street, Newcastle-upon-Tyne, 1. **E. & W. Ridings (Leeds),** 4 Hillary Place, Leeds, 2. **E. & W. Ridings (Sheffield),** 45 Rutland Park, Sheffield, 10. **North Midland,** 1 Granville Road, Leicester. **Eastern & Southern,** 38-39 York Terrace, Regents Park, N.W.1. **London (North),** City Gate House, Finsbury Square, E.C.2. **London (South)** Minster House, 272 Vauxhall Bridge Road, S.W.1. **South Western,** 19 Woodland Road, Bristol, 8. **Wales,** Graham Buildings, Newport Road, Cardiff. **Midland (Birmingham),** Somerset House, 37 Temple Street, Birmingham, 2. **Midland (Wolverhampton),** Queen's Arcade Chambers, Queen Square, Wolverhampton. **North-Western (Manchester),** 72 Bridge Street, Manchester, 3. **North-Western (Liverpool),** West Africa House, 25 Water Street, Liverpool, 2. **Scotland,** 37 Kenfield Street, Glasgow, C.2.

Zerox U.K. Development

CO-OPERATION between Whiffen & Sons Limited and the Alfloc water treatment service of Imperial Chemical Industries Limited will help the development in the United Kingdom of the use of Zerox (35% hydrazine solution) for the de-oxygenation of boiler feed water. Deliveries of Zerox and technical advice on its use will be available from Whiffen & Sons Limited, Fison House, 95 Wigmore Street, London, W.1. or from Alfloc Water Treatment Service, in the latter case via I.C.I. Sales Offices.

Drage Instruments Agreement

IN agreement with Aktiengesellschaft Chemisches Institut Dr. A. G. Epprecht, Zürich, Short & Mason Limited, Aneroid Works, 280 Wood Street, Walthamstow, London, E.17, will act as sole agents in Great Britain for the range of Drage instruments. In addition, the new Drage Multitest tensile, compression and bending test machine will be available through Short & Mason Limited.

Contracts and Work in Progress

DAVID BROWN MACHINE TOOL DIVISION, Manchester.—Large turbine gear cutting machine for Swedish electrical engineering concern. Over 50 of these machines totalling over £3,000,000 have now been supplied to various foreign countries.

R. Y. PICKERING & COMPANY LIMITED, Wishaw.—Contract for 1,364 freight wagons and 400 cattle wagons for the Pakistan Government Railways.

F. PERKINS LIMITED, Peterborough.—3,050 diesel engines for Yugoslavia. A total order value of £2,500,000 has now been received by this company from Yugoslavia since 1955.

RUSSELL, NEWBERY & COMPANY LIMITED, Dagenham.—Order for 65 diesel engines for the National Iranian Company for use in the Iranian oilfields.

METROPOLITAN - VICKERS ELECTRICAL EXPORT COMPANY LIMITED, Manchester—Order from Agua y Energia (Argentine Power and Water Board) for the supply and construction of seven 132,000-V substations for installation in the Buenos Aires City area. The order, approaching £5M in value, is the largest order for this type of equipment ever placed with the company.

DAVY & UNITED ENGINEERING COMPANY LIMITED, Sheffield.—New slabbing mill, value over £500,000, for Appleby-Frodingham Steel Company (a branch of The United Steel Companies, Limited).

WINSTON ELECTRONICS, LIMITED, Shepperton, Middlesex.—Electronic equipment for Italy valued at over £70,000. The equipment includes spectrum analysers and highly stabilized decade oscillators.

THE HUNSLET ENGINE COMPANY LIMITED, Leeds.—Order for four 274 H.P. 0-6-0 type diesel-hydraulic locomotives for Madras Port Trust.

THE GENERAL ELECTRIC COMPANY LIMITED, London.—Order through Canadian Department of National Defence for motor-driven centrifugal compressor for installation at the National Aeronautical Establishment, Ottawa, Canada. Valued at over £140,000.

SIEMENS-EDISON SWAN LIMITED, London.—Power and control cables and accessories for 15 kV, 3 kV and 1,100 V working for Mundo Nobo power station, Curacao, Dutch West Indies. Order placed through Metropolitan-Vickers Electrical Company Limited, main contractors.

AVELING BARFORD LIMITED, Grantham.—Twenty-two of the 170 10-ton 115 h.p. graders to be supplied to the Argentine Government were conveyed to London Docks by a British Railways special train last month for loading on the s.s. Argentina.

NATIONAL GAS & OIL ENGINE CO. Limited.—Order from the Industrial Development Corporation of Burma for three B4AUP8 pressure-charged dual fuel engines, each driving a 1450 kW Brush alternator for the Thayethmyo District cement mill in Burma.

Contract through Brush Aboe (Canada) Limited, for two National B2AUP6 pressure-charged dual fuel engines for a Canadian sewage plant—the Ashbridges Bay Sewage treatment plant in Ontario.

Film News

A Measure of Maxam—Produced by the Maxam division of the Holman group, this film deals with the application of pneumatic and associated equipment for the automatic control of production processes and shows the manufacture and assembly of Maxam valves, cylinders and solenoids. The film shows the equipment at work in a number of industrial premises including aeronautical engineering works and quarries. Further information may be obtained from Mr. D. Gwynne Jones, Press and Public Relations Limited, 47/48 Berners Street, London W1.

Materials Handling.—A list of films on this subject has been compiled and is available (upon receipt of a stamped addressed envelope) from the Secretariat, National Joint Committee on Materials Handling, 20/21 Took's Court, Cursitor Street, London EC4. Some 60 titles are listed showing size, running time (where known), source, synopsis, and audience suitability.

Long Service Awards

A FURTHER ten employees of James Neill & Company (Sheffield) Limited completed in April last 25 years service, and were presented with gold watches to mark the occasion. This brings the total of recipients of the award up to 92.

Trade Literature

Axial, Propeller and Centrifugal Fans

Three new publications, Nos. 30, 32 and 39 have been issued by Keith Blackman Limited, Mill Mead Road, London N17.

Publication No. 30 is a 40 p. catalogue dealing with Tornado Type AFX, V-rope driven seven and eight bladed axial fans, all impellers being fitted with cast silicon-aluminium, aerofoil section blades. Fan sizes range from 16 to 48 in. dia.

Publication No. 32 deals with Tornado Type APA propeller fans of 6 to 48 in. dia. These three bladed propeller type fans, direct driven by totally enclosed motors manufactured by Keith Blackman specifically for fan application are constructed in accordance with BS.170:1939 and BS.2613:1935.

Publication No. 39 relates to Tornado Type EK, V-rope driven centrifugal fans and covers the forward curved, multi-vane type of fan in sizes from Nos. 6 to 72. Three basic drive arrangements are covered, the overhung drive or LK rig; the fabricated or cast iron pedestal rig with double bearings, and the double bearing, bearer bar rig.

Fifty Pneumatic Control Circuits

A valuable source of reference for all concerned with pneumatic control devices and equipment is to be found in a well bound handbook entitled "Maxam Pneumatic Equipment for Production—50 Typical Circuits" published by the Maxam Division of The Climax Rock Drill & Engineering Works Limited, Carn Brea, Redruth, Cornwall, who will be pleased to supply copies free of charge on request. Each left-hand page carries a circuit diagram and the facing page the sequence of operations.

Self-lubricating Bearings

Three new "dry" bearing materials have been announced by The Glacier Metal Company Limited, Alperton, Wembley, Middlessex.

The first DU, comprising thin steel strip with a porous bronze coating impregnated with a mixture of P.T.F.E. and lead is claimed to provide three times the load/speed carrying capacity of the Company's original DP material which it now supersedes. DQ, a fluoro-carbon (P.T.F.E.) strengthened with special fillers and supplied in bars and tubes, and finally DM—a process for applying an adherent layer about 0·0015/0·0025 in. thick of a combination of fluoro-carbon and molybdenum disulphide to the bearing surfaces of customers' parts sent for treatment.

Complete File Service

A leaflet from Cowley & Pitt Limited, Pensnett Trading Estate, Brierley Hill, Staffs., draws attention to their complete file renovation service. They undertake to electro-chemically resharpen worn files at approximately third the cost of a new file and machine recutting at less than half the cost.

Machinery and Accessories for Sheet Metal Fabrication

Benders, cutters, folders, guillotines, nibbling machines, presses, punching and shearing equipment are amongst the multitude of items illustrated in the new 34 pp catalogue SM.458 published by F. J. Edwards, Edwards House, 359–61 Euston Road, London NW1. Also included in this edition are selections of machine tools, wood-working machinery and tin box making machines.

Marine Pressure Sets

A range of unit pressure sets for marine water systems, introducing several original design features, is now being produced by Megator Pumps & Compressors Limited, 43 Berkeley Square, London W1. These Megator unit pressure sets, in which the pumps, control gear and all accessories are pre-assembled on a steel framework, with all inter-connecting piping and wiring completed, are claimed to combine the advantages and economies of standardization and factory assembly with the flexibility of design necessary to meet the requirements of different shipowners. A booklet has been published giving design and selection data on pressure systems employing the new sets, and copies are available on application.

Plain Talk on Beryllium

Coming somewhat in the nature of a postscript to a review in our last issue* of the work conducted in a beryllium research laboratory, we have received a copy of "Plain Talk on Beryllium" a pamphlet published by The Beryllium Corporation, P.O. Box 1462, Reading, Pennsylvania, U.S.A., which deals with industrial hygiene aspects of beryllium, its oxide and alloys. Obviously a brief pamphlet (12 p.) can only touch the surface of the problems related to handling and fabricating these toxic materials, but its contents does provide a useful introduction to the subject and the bibliography gives sources of information for more detailed study. Under separate headings the pamphlet deals with the metal, oxide, soluble compounds and casting and wrought alloys. Copies also are freely available from the Beryllium Smelting Company Limited, 36/38 Southampton Street, London WC2.

*May, 1958 pp. 226-227.

New Factories

Birtley (Co. Durham). Plans have been approved for proposed works extensions covering 64,000 sq. ft. for Caterpillar Tractor Company Limited.

Blyth. J. R. Rutherford & Sons, Jesmond, Newcastle-on-Tyne, have received the contract for civil engineering work for a proposed substation for the Central Electricity Generating Board.

Boldon. Gordon Durham & Company, East Bolden, have received a contract for the construction of vehicle maintenance and repair workshops for the Main Road Garage.

Carlisle. Johnston & Wright, 13 Castle Street, are the architects for warehouse, offices and garages on the Durranhill industrial estate, for W. B. Anderson & Sons, Limited.

Plans have now been approved for the erection of a large factory at Dalston, near Carlisle, for the Nestle Company Limited, Hayes, Middlesex, on a 70 acres site at Low Mill Farm. The architect is H. J. Harvey, F.R.I.B.A., 8-10 King Street, Hammersmith, London, W.6.

J. K. Innes & Company Limited, are to extend their Kingmore Works to provide a blacksmith's shop, and technical and commercial offices.

Dumfriesshire. Richardson's Moss Litter Company Limited, The Crescent, Carlisle, are to construct a factory at Nutberry Moss, Eastriggs, and planning permission has been granted.

Felling (Co. Durham). Outline plans for clothing factory and offices in Stoneygate Lane for White & Company Limited, St. Andrew's Street, Newcastle have been approved. The architects are J. G. Cowe & Son, Claremont Chambers, Claremont Place, Newcastle-on-Tyne.

The Urban Council has approved outline plans for a large garage and depot in Stoneygate Lane for Road Services (Caledonian) Limited, Glasgow Road, Dumfries.

Hebburn-on-Tyne. The National Coal Board, Shotley Bridge, Co. Durham, are to erect additional buildings at Monkton Coke Works.

Jarrow. The Mercantile Dry Dock Company Limited have decided to go ahead with their proposed new dry dock which will be large enough to accommodate ships of about 18,000 tons. The consulting engineers are R. T. James and Partners, Clavering Place, Newcastle-on-Tyne.

Middlesbrough. British Railways (North-Eastern Region), York, are to start work next year on the construction of a new marshalling yard at Middlesbrough to cost between £3,000,000 and £4,000,000.

A. Hinton & Sons, South Street, and Appleyard & Sons, Albert Road, are planning warehouses and garages at Albert Mews.

R. Cowan, 20 Finkle Street, Stockton is the architect for rebuilding the fellmongery for the Middlesbrough District Hide and Skin Market Company Limited.

The Tees Valley and Cleveland Water Board have accepted the tender of Monk & Company Limited, Albert Road, Middlesbrough for the construction of

Continued over

a building 100 ft long and 50 ft wide to house the micro-straining plant at Long Newton Reservoir.

Murton (Co. Durham). The Northern General Transport Company Limited, Gateshead are to extend their Murton garage to accommodate another 40 buses, to erect new workshops, and to modernise their offices. The architect is R. C. Cowmeadow, Slad, Stroud, Gloucester.

Newcastle-on-Tyne. Cussins Limited, contractors, The Drive, Gosforth, are to spend £2,000,000 on the construction of large block of shops and offices and car-parking station to accommodate 500 cars.

R. B. Charlton & Company Limited, Manors Brass Works, are to extend their factory in White Street, and have prepared their own plans.

Penrith. Redmayne & Sons Limited, Castletown, are to buy about 4,600 square yards of land in the Gilwilly area for future factory developments.

Stanley. Durham Divisional Coal Board are to erect a coal-washing plant at Morrison Busty Colliery.

Stockton-on-Tees. Charles Clifford Limited, Birmingham, are in touch with the Town Council regarding the acquisition of 5,500 sq yds of land for industrial developments for Metallisation Limited, Dudley, a subsidiary of the Birmingham firm.

Thornaby-on-Tees. British Road Services are planning a rebuilding scheme at their depot in Chapel Street, Thornaby. At present paving and drainage work is being carried out by Tarslag Limited, Bowesfield Lane, Stockton-on-Tees, but no detailed plans have been prepared for the rest of the work. Plans are by B.R.S. Surveying and Architectural Dept. (New Works Section).

Tynemouth. Messrs. Smith's Dock Company Limited, North Shields, are to erect a blacksmith's shop, and extend their erecting shop.

Two storage sheds are proposed in Wallsend Road for Stella Building Products, to plans by H. Gatoff, 51 Grainger Street, Newcastle-on-Tyne.

The Tyne Improvement Commission, Bewick Street, Newcastle upon Tyne are to erect wagon repair and platers' shops at Albert Edward Dock, North Shields. No contracts let. The Commission's chief engineer is Mr. R. B. Porter.

Basildon. A new factory is to be erected on the Nevendon industrial estate for Ilford Limited, Ilford.

Basingstoke. The factory of Hallzone Limited, Coronation Road, is to be extended.

Bolton. Law & Grimshaw, Bank Chambers, Market Street, Atherton are the architects for the new factory and offices to be built at Burnden Bleach Works for W. J. Kenyon & Company (Sheet Metal Workers) Limited.

Bridgnorth. The Atar Aluminium Company are to make extensions to their works in Stourbridge Road.

Brighouse. Extensions are to be made to North Vale Mills, Bailiff Bridge, for the North Vale Doubling Company Limited.

Burnley. The Regent Axle Company Limited, Marles Street, are to erect a new factory at Rileys Farm, Rossendale Road. The architects are Houston & Forbes, Old Black Bull, Church Street, Padiham.

Burton-on-Trent. The Midland Joinery Works Limited, are to build a new factory at Bond End Wharf.

Chorley. Richard Baxendale & Sons Limited, Albert Street, are to erect a new factory at Coppull.

Croydon. F. Broomfield Limited, 322 Whitehorse Road, have applied for a site for a new factory.

Dover. Kenex Coachworks Limited, are to make extensions to their works at Barwick Road.

Dudley. Extensions are to be made to the works of A. Perry & Company Limited, Doulton Road.

Dunmurry. The Ministry of Commerce is to erect a new factory for lease to Tolimit Gauges Limited, Peterborough Road, Fulham.

Edinburgh. C. G. Dobson Limited, Yeaman Lane are to erect new workshops and stores.

Fareham. A new factory is to be erected for Searle Radiators & Refrigeration Limited, 2 Quay Street. The contractors are E. H. Burgess Limited, 34 Grosvenor Gardens, London, S.W.1.

Glasgow. G Reid & Sons Limited, Catrine, are the contractors for the new machine shop for A. P. Newall & Company Limited, Woodside Engineering Works, Possilpark, Glasgow, N.2.

Godalming. Plans have been approved for extensions to the works of W. F. Paine Limited, Highfields, Brighton Road,

Havant. A new factory is to be erected for Tampax Limited, Belvue Road, Northolt, Greenford. The architects are E. J. Thomas, Jolly & Grant, 26 Kent Road, Southsea.

Hounslow. New workshops and offices are to be built at Gunnersbury Works, London Road, for Roadless Traction Limited. The architects are W. E. & E. M. Cross, Osterley Road, Isleworth.

Hull. Extensions are to be made to the works in York Street of Weeks (Engineers) Limited, 78-80 Oxford Street.

New workshops and offices are to be built at Blackfriargate for C. Rosindale & Son.

London. A new factory and offices are to be built in Lassell Street, London, S.E.10 for W. Hughes & Son Limited, 74 Bonner Road, London, E.2. The architects are C. Living & Son, 233 Leytonstone Road, London, E.15.

Extensions are to be made to the works of Pirelli General Cable Works Limited, Fitzroy Street, London, W.1. The architects are D. & J. D. Wood, 1 Old Burlington Street, London, W.1.

Mansfield. Extensions are to be made to the factory in Victoria Street for Whittey Electrical Radio Company Limited.

Newport. The Steel Company of Wales is to spend £2,000,000 on the expansion of their Orb Works.

Nuneaton. Extensions are to be made to the factory of Form Shoes Limited, Weddington Road.

Oxford. Metalip Manufacturing Company are to erect a new factory in Old High Street, Headington.

Ratho. A new factory is to be built for John E. Young & Company Limited, Bonnyrigg, Lasswade.

Romford. Plans have been approved for the erection of a new factory on the Crow Lane industrial site for T. J. Brooks & Company (Metals) Limited.

Extensions are to be made to the factory at Tonbridge Road for F. B. & M. Limited, Farrington Avenue, Harold Hill.

Ruislip. Express Dairy Company (London) Limited, 15 Tavistock Place, London, W.C.1. are to erect a new butter-making factory in Victoria Road.

Salford. Permission has been received for the erection of a new works on a site in Blackfriars for J. W. Jackman & Company Limited, foundry engineers.

Sedgley. A new foundry is to be erected on the Dormston trading estate, Burton Road, Upper Gornal for Northwood Metals Limited.

Sutton Coldfield. Extensions are to be made to the factory at Reddicap industrial estate for Moulded Plastics (Birmingham) Limited.

Swansea. Extensions are to be made to the works at Upper Bank for Road & Rail Wagons Limited.

Tunbridge Wells. H. E. Daniel Limited, Longfield Road, are to erect a new factory.

Welwyn. Smith, Kline & French Laboratories Limited, 120 Coldharbour Lane, London, S.E.5, propose to erect new premises.

Weybridge. The works of Peto Scott Electrical Instruments Limited, Addlestone Road, is to be extended.

Jedburgh. A £200,000 factory is to be built at Hartrigge, Jedburgh, by Roxburgh County Council for the L. S. Starret Company of Athol, Massachusetts, U.S.A. This British subsidiary of the parent company will produce a wide range of tools for the British and European markets. Initial labour force will be 100, but this is expected to increase substantially. Start of production scheduled for 1959.

Alloa. Harland Engineering Company Limited has opened a new water turbine engineering shop to handle hydro-electric work. They are also developing a new hydraulics research laboratory.

Aberdeen. Richards Limited, flax spinners and textile manufacturers, have carried out development costing £750,000, some of which has already been completed.

Dysart, Fife. The National Coal Board in Scotland is completing a central workshop of 44,000 sq ft at Dysart to maintain and overhaul mining machinery for the Fife area. A new central stores block has been also added.

Leven, Fife. The Balfour Group has begun work on their £130,000 research and development centre at Leven. This will be the central research unit for the group and will incorporate a range of workshops, testing sections and laboratories for metal, gas and fluid research concerned mainly with chemical engineering problems.

Perth. British Railways are to spend £800,000 on new marshalling yard facilities at Perth, involving £450,000 on civil engineering work. A part of this work has been completed but the mechanical and electronic aspects remain to be done.

Speyside. Schenley Industries Inc., through Seager and Evans Limited are to extend their distillery facilities and warehousing space at Glenugie Malt Distillery, near Peterhead. Work has also begun on a new distillery on Speyside.

Northern Ireland. A second 100,000 sq. ft. extension is to be made to the Castlereagh works of British Tabulating Machine Company Limited.

Ulster Chipboard Limited have completed negotiations for a factory of 19,000 sq. ft. at Castleroe, Coleraine, Co. Londonderry.

Supak Limited of Perivale, Middlesex, have acquired Berets Industries Limited and its subsidiary, the Cookstown Weaving Company Limited and are expanding production in the 30,000 sq. ft. factory at Cookstown, Co. Tyrone.

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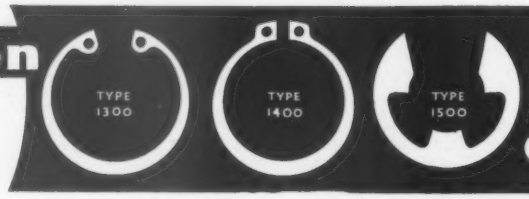

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